REPORT RESUMES

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AN ANALYSIS OF LEARNING EFFICIENCY IN ARITHMETIC OF MENTALLY RETARDED CHILDREN IN COMPARISON WITH CHILDREN OF AVERAGE AND HIGH INTELLIGENCE.
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A COMPARISON OF THE LEARNING EFFICIENCY IN ARITHMETIC OF MENTALLY RETARDED CHILDREN AND CHILDREN OF AVERAGE AND HIGH INTELLIGENCE WAS MADE. THIS STUDY TESTED FIVE HYPOTHESES--(1) UNEVEN PHYSICAL GROWTH ACCOMPANIES LOW EFFICIENCY IN LEARNING ARITHMETIC, (2) SLOW PHYSICAL GROWTH ACCOMPANIES LOW EFFICIENCY IN LEARNING ARITHMETIC, (3) THE LEVEL OF FUNCTIONING AS REPRESENTED IN STRENGTH, MENTAL AGE, READING ACHIEVEMENT, LANGUAGE ACHIEVEMENTS, AND ARITHMETIC ACHIEVEMENT IS THE SAME AMONG MENTALLY RETARDED, AVERAGE, AND HIGH IQ CHILDREN, (4) SPEED OF ACQUIRING ARITHMETIC LEARNING IS INVERSELY RELATED TO RETENTION AMONG GROUPS OF CHILDREN OF LOW, AVERAGE, AND HIGH IQ, AND (5) RATE OF FORGETTING ACQUIRED ARITHMETIC LEARNINGS IS EQUAL AMONG CHILDREN OF LOW, AVERAGE, AND HIGH IQ. THE MEASURES EMPLOYED IN THE TESTING OF HYPOTHESES 1, 2, AND 3 WERE HEIGHT, WEIGHT, STRENGTH, CARPAL DEVELOPMENT, PERMANENT TEETH, INTELLIGENCE, AND ACHIEVEMENT TEST RESULTS IN READING, ARITHMETIC, AND LANGUAGE. TESTING OF THE LAST TWO HYPOTHESES REQUIRED INDIVIDUAL ADMINISTRATION OF ARITHMETIC LEARNING TASKS OVER A PERIOD OF TIME. COMPLETE PERSONALITY ASSESSMENTS AND MEDICAL EXAMINATIONS, ALONG WITH PERTINENT EDUCATIONAL AND FAMILY HISTORIES WERE OBTAINED ON THE MENTALLY RETARDED FOR DESCRIPTIVE PURPOSES AND POSSIBLE COMPARISONS WITH OTHER MENTALLY RETARDED CHILDREN. IT WAS CONCLUDED THAT THE EVIDENCE STRONGLY SUGGESTS THAT THERE IS NO DIFFERENCE IN RETENTION OF ARITHMETIC LEARNINGS AMONG CHILDREN OF LOW, AVERAGE, AND HIGH INTELLIGENCE WHEN THE LEARNING TASK IS GRADED TO EACH CHILD'S CURRENT ACHIEVEMENT LEVEL AND RETENTION IS MEASURED IN UNITS OF PRACTICAL ARITHMETIC EXERCISES OR IN TIME TO LEARN OR RELEARN TO SOLVE A NOVEL ARITHMETIC PROBLEM. (AH)

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AN ANALYSIS OF LEARNING EFFICIENCY IN ARITHMETIC OF MENTALLY RETARDED CHILDREN IN COMPARISON WITH CHILDREN OF AVERAGE AND HIGH INTELLIGENCE

OFFICIAL RESEARCH FILE COPY

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AN ANALYSIS OF LEARNING EFFICIENCY IN ARITHMETIC OF MENTALLY RETARDED CHILDREN IN COMPARISON WITH CHILDREN OF AVERAGE AND HIGH INTELLIGENCE

I INTRODUCTION

PURPOSES

Efficiency of learning and retention and the relationships among various physical, achievement, and personality measures in mentally retarded children is of significance to society generally, to those responsible for the education of mentally retarded children, to those concerned with theory of school learning and behavior, and to those interested in the science of individual differences. In this study, children of average and high intelligence served as control groups for the mentally retarded, thus extending the scope of possible significance.

Society has long been and is currently concerned with mental retardation. However, in recent years, there has been a marked shift from institutionalizing educable mentally retarded children to keeping them at home, educating them in special classes for the retarded, and eventually placing part of them in gainful occupations. Thus, whereas adults in many communities formerly had little contact with the mentally retarded, they now find these children and youth in the same neighborhood and school, associating with children and youth of all levels of ability. Though many educable mentally retarded children are now residing in their homes, information is scattered as to what may be expected of them in terms of physical development and health, educational achievements, and personality development. This study provides additional information on these matters and should prove of value to community-school groups in planning and executing programs for educable mentally retarded.

Teachers, school psychologists, and curriculum workers in special education programs for the mentally retarded are operating with incomplete information about the learning-retention characteristics of mentally retarded children in general. Further, little research has been designed to deal with the learning-retention, physical, achievement, and personality characteristics of mentally retarded children in comparison with the other children residing in the same community and attending the same schools. The present study provides reliable information on the development of children of varying levels of intelligence. Teachers of mentally retarded children, school psychologists, and curriculum workers can use the results in the development of learning activities appropriate for the mentally retarded.

One of the most important factors in school learning and behavior is the pupil. The teacher, the curriculum and administrative pattern, the community, the services provided to teacher and pupils, and the goals of instruction are also important factors in school learning and behavior. However, the child as he comes to school sets some limits, regardless of the educational provisions, upon how well he can learn, how he behaves, and what kind of an adult he will eventually be. This study focuses upon pupils of low intelligence in comparison with children of average and high intelligence, all attending public school classrooms that are operating under generally excellent and replicable conditions. The descriptions and comparisons of the three groups clarify the pupil factor in school learning theory.

Generalizations about human differences are now being offered in popular and professional literature which are in part based upon psychological studies completed before 1930. Since 1930, however, three major changes have occurred which may raise doubts about the accuracy of some of the generalizations. First, the change from institutionalizing mentally retarded children to keeping them at home and sending them to special classrooms is a recent development. This change of environment may markedly affect their physical, educational, and personality development. Second, most of the various federal, state, and local laws which provide many forms of assistance to needy families were enacted since 1932. Families of low income, from which many retarded children come, are receiving better housing, food, medical attention, and the like than they were prior to the 1930's. Third, many significant discoveries in nutrition and medicine have been made in the past twenty years. The benefits of these discoveries are increasingly made available to all children. Thus, environmental differences between mentally retarded children and bright children are less marked than in 1930 and possibly may be relatively small in the three areas discussed. Since these changes in environment may affect the measures investigated, this study should contribute significantly to the science of individual differences.

The above statements of significance imply the broad scope of this study, the main purpose of which was to test the following hypotheses.

1. Speed of acquiring arithmetic learning is inversely related to retention among groups of children of low intelligence (IQ 55 to 80), average intelligence (IQ 90 to 110), and high intelligence (IQ 120+). This hypothesis implies that high IQ children learn rapidly and forget rapidly whereas low IQ children learn slowly and forget slowly.

2. Retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level. This hypothesis proposes that if an arithmetic learning task is appropriately graded to the present achievement level of each child, there will be no difference in retention among the three IQ groups. Speed of learning is not a critical factor in testing this hypothesis.

3. Uneven physical development within the child accompanies low efficiency in arithmetic achievement and in reading acheivement. This hypothesis deals with the phenomenon of split-growth and implies that the more unevenness, the lower the achievement.

4. A low level of physical development within the child accompanies low achievement in arithmetic and reading. This hypothesis suggests that the lower the level of physical development, the lower the achievement in arithmetic and reading.

5. The within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithemtic achievement is the same among children of low, average, and high intelligence. Stated differently, the low IQ children as a group are equally low within themselves in all five measures, the average IQ are equally average, and the high IQ are equally high. A truncated hypothesis is that the levels of functioning as shown in reading achievement, leaguage achievement, and arithmetic achievement are the same among children of low, average, and high intelligence. Originally, the main hypothesis was stated as follows: the level of functioning within the child as shown in strength, intelligence, reading achievement, language achievement, and arithemtic achievement is the same among children of low, average, and high intelligence. The researchers experienced difficulty in communicating to others the concept of level of functioning as embodied in the hypothesis, but little difficulty with the concept of within-child variability. Therefore, the hypothesis is stated in its present form. It will be noted subsequently in the discussion of design that the within-child score is a measure of the consistency among the levels of the five measures.

The other main purpose of the investigation was to ascertain the relationships among the physical, achievement, and personality measures and the differences among the three IQ groups in each measure.

DESIGN

Six main features of the overall design are now given. Twenty boys and 20 girls were selected for each IQ group of 40 on whom the intensive data were gathered. All the children were enrolled in public school classrooms.

All the children were drawn by the same criteria in 1956-57, 1957-58, and 1958-59; and essentially the same children were in the study in 1958-59 as in 1957-58. Chronological age was the same for the three groups of children, with all children having birth dates between September 15, 1947, and December 15, 1948. Socially useful and meaningful arithmetic learning tasks were used in testing the acquisition-retention hypotheses. Physical, achievement, and personality measures purportedly related to school success, were used to ascertain if differences existed among the three IQ groups.

A brief overview of the design related to each of the purposes previously stated follows. In subsequent sections of this report, more information is presented about the children and the measures.

Hypothesis 1, dealing with the inverse relationship between learning and forgetting, was tested in 1957-58, using time scores obtained from administrations of the same problem to all 120 children. The score used to measure the inverse relationship between acquisition-retention was the ratio between time to acquire and time to relearn at specified intervals after acquisition. Analysis of variance was used to test the significance of difference among means by sex and IQ level.

Hypothesis 2, dealing with retention of arithmetic learnings graded to each child's achievement level, was tested twice in 1957-58 and twice in 1958-59, using the three groups of 40 children. The learning-retention tasks involved counting, adding, subtracting, and differentiated problem-solving and were administered individually to each child. In the first three tasks, the score used in testing the hypothesis was the number correct of ten items; in the last task a time score was used. The significance of difference among means by sex and IQ groups was tested by analysis of variance and covariance.

Hypothesis 3, dealing with uneven physical development and achievements, was tested in each of the three years. Forty boys and 40 girls were drawn from a larger child population but included some of the 120 children in the main group. These children were drawn to fit a Gaussian curve based on the WISC. In each sex group one child was drawn with an IQ below 70, five with IQ's of 70-84, fourteen with IQ's of 85-99, fourteen with IQ's of 100-114, five with IQ's of 115-129, and one with an IQ of 130 or higher. Uneven physical development was defined as the sum of the differences of the height, weight, strength of grip, and carpal age scores from the child's own mean score in the four measures. (Dentition was omitted because of inconsistent relationships with the other four physical measures.) Raw scores were changed to Z-scores, using the means and standard deviations of the two sex groups of 40, in order to secure comparable units of measurement. Correlations were run between the obtained scores and scores from standardized tests of arithmetic and reading.

The example which follows shows the derivation of the measure of uneven physical development:

A child's Z-scores were -.036 in height, -.106 in weight, +.202 in grip, and -1.572 in carpal. Add these 4 scores algebraically to obtain -1.512; then divide by 4. The result is -.378, the mean level of physical development score. To obtain the measure of uneven physical development, find the sum of differences between each of the child's 4 Z-scores and his mean level of physical development; (-.378) - (-.036) = -.342; (-.378) - (-.106) = -.272; (-.378) - (+.202) = -.580; (-.378) - (-1.572) = +1.194. The sum of these differences, 2.388, disregarding signs in adding, is the measure of variability in physical development.

Hypothesis 4, dealing with the level of physical development, was tested with the same children and in the same manner as Hypothesis 3, with level of physical development defined as the average of each child's Z-scores in height, weight, strength of grip, and carpal age. The previous example illustrating the derivation of the measure of uneven physical development shows also the derivation of the measure of the mean level of physical development.

Hypothesis 5, dealing with variability in functioning within the child, was tested in each of the three years, also. Each child's scores were first changed to Z-scores, using the means and standard deviations of the 40 normally distributed boys and girls. The means and standard deviations of the normally distributed groups were used because the three discrete samples of 40 in the main study obviously yielded abnormally high standard deviations on each measure positively correlated with intelligence. The within-child variance score for each of the 120 children was first computed and subsequently the square root was extracted to alleviate possible skewness in the distribution. The obtained scores were then submitted to analysis of variance to ascertain the significance of difference among means by sex and IQ groups. The truncated hypothesis was tested by the same procedure. The method for computing the within-child variability score is now given. A child with Z-scores of -.173 in grip, .293 in IQ, -.133 in reading, .053 in arithmetic, and .132 in language has a within-child variability score of 173. The formula for within-variance, $s^2 = \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{N}}{N}$, was used. The square root of the variance was then taken and the result multiplied by 1000 to eliminate decimal points.

Correlations were run to ascertain the relationships among the various physical, achievement, and personality measures of the 60 boys and 60 girls in the main sample. It is noted that since there were 20 low and 20 high IQ children of each sex, the resulting correlations among all variables positively correlated with intelligence are higher than would be found with a normally distributed sample. Analysis of variance and the Tukey test were used to ascertain significance of difference by IQ level and sex on each of the measures.

Tests of homogeneity of variance, with few minor exceptions, showed the variance on all measures not significantly different among the three IQ groups at the .01 level and in most instances not at the .05 level. In all tests of differences, the .01 level of significance was accepted as a real difference; however, differences significant at the .05 level are also reported. Edwards, (1950); McNemar, (1949); Snedecor, (1955); and Walker and Lev, (1952) were the principal sources of statistical information used in the study.

BACKGROUND AND PILOT STUDY

In 1955-56, a study dealing with the relationships among physical and achievement measures in children enrolled in regular third- and fifth-grade classes was begun with financial support from the Graduate School of the University of Wisconsin and was subsequently reported by Gleason (1956), Gleason and Klausmeier (1958), and Klausmeier, Lehmann, and Beeman (1959). In January, 1957, a cooperative research project was started between the United States Office of Education, Department of Health, Education, and Welfare and the University of Wisconsin to achieve the purposes previously stated. A pilot study was started immediately to develop procedures to be used with the mentally retarded children. Children in special classes for the educable mentally retarded in Madison and Milwaukee were identified. After preliminary trials with a few low IQ children, the adaptation of testing materials and other measuring devices for the five physical and three achievement measures proved satisfactory. Measures of height, weight, strength of grip, number of permanent teeth, bone development of the hand and wrist, reading achievement, arithmetic achievement, and language achievement were then secured on 40 low IQ children in the special classes; and the procedures for assessing personality were planned and executed with seventeen low IQ children in Madison.

In order that the low IQ children's measures of height, weight, strength of grip, carpal, dentition, reading achievement, language achievement, and arithmetic achievement would be comparable to the same measures gathered on the children already in the longitudinal study, it was necessary to change the measures of the low IQ children, gained in February, March, and April, 1957, to October, 1956, the month in which they were secured in the longitudinal study. Thus, the scores of the low IQ children were reduced by four, five, or six months using the following formula: $\text{ORS} - \frac{\text{ORS}}{\text{CA}} \times 1 = \text{RRS}$; where ORS is the obtained raw score in 1957, CA is the chronological age of the subjects on the date of measuring, 1 is the increase in the measure expected during a four, five, or six month interval, as based on national norms, and RRS is the reduced raw score. To clarify the procedure, the following example gives the reduced raw score in height for a boy who was 113 months of age in April when a height of 53.37 inches was obtained. On norms reported by Olson and Hughes (1950), the average increment expected for boys in height between age 108 and 114 months was found to be .10 inches. This boy's reduced score was $53.37 - \frac{53.37}{113} \times 1.0 =$ 52.90. Subsequent analysis of the data showed the reduction procedure did not interfere with testing Hypotheses 3, 4, and 5, previously stated. The results of testing the hypotheses based on the data gathered in 1956-1957 are subsequently reported.

The procedures used and developed in securing the measures with the low IQ children were followed with minor variations during the next two years. While the children selected in 1956-1957 were adequate for the pilot study, most of the average and high IQ children were not available in 1957-1958. Further, the low IQ children were not screened as carefully with respect to the distribution of CA and on other criteria as was subsequently done in 1957-1958.

The remainder of this report gives a description of the children, a description of the measures, the results, a discussion of the results, and a summary and conclusions.

II THE CHILDREN

The main purpose of presenting the descriptive information in this section and the large body of additional information in the Results section is to permit possible replication of the study by other researchers and to describe the children fully so that persons working with other children can evaluate the results. In this section are presented the criteria of selection; information concerning the general, dental, and mental health of the children; occupations of the fathers; and etiology applied to the mentally retarded children.

CRITERIA OF SELECTION

The children in this study were enrolled in the Madison and Milwaukee Public Schools. Essentially the same 120 children were used during the two years, 1957-1958 and 1958-1959 in testing the hypotheses and for the supplementary descriptive data. However, a small number of additional subjects were tested in 1957-1958 to be retained as possible replacements should drop-outs occur. In addition, some children from the longitudinal study were included each year to secure an adequate random sample to test Hypotheses 3 and 4 directly and to supply means and standard deviations for the measures used in testing Hypothesis 5.

The main sample consisted of 20 boys and 20 girls of low intelligence, 20 boys and 20 girls of average intelligence, and 20 boys and 20 girls of high intelligence, a total of 120. The main criteria of selection were IQ; birth date between September 15, 1947, and December 15, 1948; and parental approval to participate in the study. Low intelligence was defined as an IQ of 55 to 80 as ascertained with the Wechsler Intelligence Scale for Children, average intelligence as a WISC IQ of 90 to 110, and high intelligence as a WISC IQ of 120 or higher. Low IQ children were excluded who exhibited the characteristics of definite organic types such as mongoloid, hydrocephalic, microcephalic, and cretin; or who were severely handicapped orthopedically or in hearing, vision, or speech; or who were suffering from epilepsy which was not under good control with medication.

Table 1 gives the means for chronological age, WISC IQ, and other information during each of the three years of the study. The mean IQ for each group of 40 by IQ level is seen to be 68.20, 103.20, and 119.48 for 1956-1957; 64.95, 102.20, and 125.80 for 1957-1958, and 66.90, 105.15, and 128.85 for 1958-1959. Table 1 also shows that the children in heterogeneous classrooms were enrolled for consecutive years in the third, fourth, and fifth grades. By the design of the study, no child who took more or less than one year per school grade was included, except in the low IQ group. The special classrooms were not organized by grade levels, hence the grade level heading is inappropriate to the low IQ children.

In 1956-1957 the 80 average and high IQ children were drawn randomly from 118 children enrolled in four heterogeneous third grade classes of three public schools in Madison and the 40 low IQ children were drawn from 58 eligible children enrolled in eleven special classes for mentally retarded educable children in Madison and Milwaukee.

In 1957-1958 the 80 average and high IQ children were drawn from 307 fourth grade children in eleven regular heterogeneous classrooms in six public schools in Madison. The 40 low IQ children were drawn from 199 children enrolled in ten special classes for mentally retarded educable children in eight public schools in Milwaukee and two public schools in Madison.

In 1958-1959 the 80 average and high IQ children were drawn from approximately 450 children in fifteen heterogeneous fifth grade classes in nine public schools of Madison. The 40 low IQ children were drawn from approximately 224 children in three special classes for mentally retarded educable children in two public schools in Madison and in eleven special classes for the mentally retarded educable in eight public schools of Milwaukee.

TABLE I

MEANS FOR CHRONOLOGICAL AGE AND WISC IQ OF THE 120 SUBJECTS IN EACH OF THREE YEARS

Group	Chronological Age			WISC IQ		
	1956-57 101 Mon. 3rd Grade	1957-58 113 Mon. 4th Grade	1958-59 125 Mon. 5th Grade	1956-57 101 Mon. 3rd Grade	1957-58 113 Mon. 4th Grade	1958-59 125 Mon. 5th Grade
20 Low Boys	104.05	113.05	124.80	71.15	66.35	69.10
20 Low Girls	104.50	112.75	124.50	65.25	63.55	64.70
20 Av. Boys	100.60	112.75	124.50	103.75	102.75	106.90
20 Av. Girls	101.90	113.00	124.90	102.65	101.65	103.40
20 High Boys	100.45	112.50	124.50	120.75	126.45	128.70
20 High Girls	90.50	111.20	122.90	118.20	125.15	129.00
40 Low IQ	104.28	112.90	124.70	68.20	64.95	66.90
40 Av. IQ	101.25	112.88	124.70	103.20	102.20	105.15
40 High IQ	99.98	111.85	123.70	119.48	125.80	128.85
60 Boys	101.70	112.77	124.60	98.55	98.52	101.57
60 Girls	101.97	112.32	124.10	95.37	96.78	99.03

CHANGES IN THE SAMPLE DURING THREE YEARS

The study was carried out chiefly on a pilot basis in 1956-1957. However, it was possible to test Hypotheses 3,4, and 5, and the results are reported subsequently as part of the overall study. An important difference between 1956-1957 and the following two years was that the roster of children changed substantially. For the three years the carryover of subjects was 13 low IQ boys, 9 low IQ girls, 3 average IQ boys, 5 average IQ girls, 1 high IQ boy, and 1 high IQ girl. In 1957-1958, 88 children were added to the 32 who remained. One hundred five children who were used in 1957-1958 continued in 1958-1959, and 10 of the 15 needed replacements were children who had been dropped randomly in excess of the 120 in 1957-1958 and on whom all the measures had been taken. The remaining five, one in each of five IQ level by sex groups, were new subjects selected by the same criteria as outlined previously and enrolled in the same schools as were the other children. The two causes of loss from 1957-1958 to 1958-1959 were the children's moving from the two cities and testing from the IQ level in which they were in 1957-1958 into a different level in 1958-1959. (Changes in IQ also produced the differences in mean IQ for 1958-1959 as shown in Table 1.)

GENERAL HEALTH OF THE CHILDREN

During the 1957-1958 school year a medical examination was given to each child in the study. The examination was performed by a physician in the nurse's office of each of the schools. Included in the medical examination were temperature, pulse rate, respiration, blood pressure, skin condition, pubic and axillary hair, eyes, ears, nose, throat, chest, abdomen, anus, the genitals, the reflexes, and any other anomalies or conditions which might be noted. On a special medical examination form (see Appendix A) 39 measurements or descriptions of condition were noted by the doctor during his examination of the areas indicated above. This information was then used to make a summary rating of general health condition of each child. Three ratings were used: (1) satisfactory health condition, (2) needs attention, and (3) needs attention urgently.

Of the 120 children in the study, 114 were found to be in a satisfactory state of health. Three low IQ girls and one average IQ boy were classified as needing attention and two low IQ girls were left unclassified. Thus, 95 per cent of the children were in satisfactory health, 3.3 per cent needed some attention, and 1.7 per cent were not classified. The physical examination was not repeated during the 1958-1959 school year because the total group of 120 children remained nearly the same as in 1957-1958. Of fifteen replacements needed in 1958-1959, ten had been in the study in 1957-1958, physical examinations had been administered to them, and no contradictions to the above results were noted in an informal inspection of the classification for general health condition of these substitutes. The researchers concluded that the children were generally in good health with no significant differences in health according to the IQ groups.

DENTAL HEALTH OF THE CHILDREN

Dentists counted the permanent teeth of the children each year and also assessed their dental health. The examining dentist classified each child's dental health as satisfactory, in need of attention, or urgently in need of attention. (Appendix B contains the forms used.)

Table 2 shows the classification for the six subgroups of 20 children by IQ level and sex for 1957-1958. Although the results were available for the other two years of the study, informal inspection of the results for those years indicated no large difference from the results in 1957-1958. Table 2 shows that 64 children or 53 per cent of the 120 had satisfactory dental health; 43 children, 36 per cent, were in need of attention; and 13, 11 per cent, needed attention urgently. Ten of the 13 children needing attention urgently were low IQ,

TABLE 2

RESULTS OF THE DENTAL EXAMINATION IN 1957-1958
ON THE 120 SUBJECTS

Group	Needs Attention Urgently	Needs Attention	Satisfactory
Low IQ Boys	4	8	7
Low IQ Girls	6	11	3
Average IQ Boys	1	7	12
Average IQ Girls	1	11	9
High IQ Boys	1	3	16
High IQ Girls	0	3	17
Total	13	43	64

2 were in the average IQ group, and 1 in the high IQ group. Similarly, only 10 low IQ children had satisfactory dental health while 21 average and 33 high IQ children were reported satisfactory. Thus, dental health is related to IQ with the incidence of satisfactory dental health increasing from 25 per cent, to 43 per cent, to 83 per cent on the three IQ groups.

PSYCHOLOGICAL HEALTH OF THE CHILDREN

Three clinical psychologists on the staff of the Wisconsin Diagnostic Center, Madison, Wisconsin, and eight school psychologists of the Madison and Milwaukee Public Schools assessed the personality of each child. The Rorschach, three cards from the Thematic Apperception Test, one Draw-A-Figure, and a clinical interview were used in one sitting with the child. The children were examined both in 1957-1958 and in 1958-1959. From these materials and subsequent ratings of six variables, the same clinical psychologist categorized the psychological health of all the children as follows: (1) intensive help needed by the child directly or intensive help needed in connection with an adverse home situation; (2) some therapy needed by the child directly or some help needed in connection with an adverse home situation; (3) no therapy needed. (Appendix C shows the forms used in the psychological assessment.)

Table 3 shows the ratings for the six subgroups of 20 children for both years. Of 120 children in 1957-1958, 90 needed no therapy or were apparently in

TABLE 3

PSYCHOLOGISTS' RATINGS OF THE CHILDREN'S NEED FOR THERAPY IN 1957-1958 AND 1958-1959

IQ Level	Intensive Therapy Needed		Some Therapy Needed		No Therapy Needed		Total	
	1957-1958	1958-1959	1957-1958	1958-1959	1957-1958	1958-1959	1957-1958	1958-1959
Low IQ Boys	3	3	2	7	15	10	20	20
Low IQ Girls	1	3	3	7	16	10	20	20
Average IQ Boys	1	1	6	6	13	13	20	20
Average IQ Girls	0	0	5	5	15	15	20	20
High IQ Boys	1	0	6	9	13	11	20	20
High IQ Girls	0	0	2	3	18	17	20	20
Total	6	7	24	37	90	76	120	120

good psychological health, 24 were in need of some therapy, and 6 were in need of intensive psychological therapy. While four of the six children who were in need of intensive therapy were low IQ children and only one average and one high, it was also true that of the 24 children who needed some therapy, 11 were average IQ, 8 were high IQ, and only 5 were low IQ. The distribution by IQ of children needing no therapy was 31 low IQ, 28 average IQ, and 31 high IQ children. In 1958-1959, the results were much the same except that the Need for Some Therapy markedly increased, and the No Therapy Needed markedly decreased for the low IQ children.

The general picture of the mental health of the children used in the study is probably not widely discrepant from similar samples of children which might be drawn in other cities of similar size and socio-economic condition. Of primary importance is the fact that only 5 per cent of the children appeared to need intensive therapy. By definition of the rating, those needing some therapy might be adequately provided for by well-qualified public school personnel, such as the school psychologist, guidance director, or counselor, and perhaps classroom teachers.

OCCUPATIONS OF THE FATHERS

The occupations of the fathers of the children used in 1957-1958 were ascertained. Since the sample remained nearly the same in 1958-1959, occupational status of the fathers was not reported for 1958-1959 although it was obtained.

Table 4 reports the occupational status of the fathers of the 120 children, based upon the occupational categories in the Dictionary of Occupational Titles (1949). While 29 fathers of the low IQ children are in the unskilled, semi-skilled and skilled occupational categories, 34 fathers of the high IQ children are in two top categories, professional and managerial and official, with little overlap among these two IQ groups. The average group clusters more in the

TABLE 4

OCCUPATIONAL STATUS OF THE FATHERS OF THE
120 SUBJECTS IN 1957-1958

Occupational Category	Low IQ Children		Av. IQ Children		High IQ Children	
	Boys	Girls	Boys	Girls	Boys	Girls
I Professional		1	4	2	7	10
II Semiprofessional				1		
III Managerial & Official		2	5	3	10	7
IV Clerical & Kindred	1	3	1			1
V Sales & Kindred			1			1
VI Service	2	1	2			
VII Agriculture, Forestry, Fishing						1
VIII Skilled	3	3	3	5		
IX Semiskilled	9	7	3	8	3	
X Unskilled	4	3	1			
Not Classified	1			1		
Total	20	20	20	20	20	20

middle categories. One readily observes a consistent relation between occupational categories and IQ level, although numerous exceptions occur.

The preponderance of professional (I) and managerial and official (II) occupations for the fathers of average and especially high IQ children may be accounted for in part by the fact that most of the average and high IQ children were enrolled in schools in which only about one-fourth of the total fathers are engaged in labor and service occupations. The low IQ children were drawn from the entire mentally retarded child population of Madison and from about 40 per cent of the Milwaukee population.

Etiology of the Low IQ Children

An attempt was made to determine whether the low IQ child's retardation was hereditary, organic, or combined. Three main types of information were secured in order to make this classification. The first type of information was that secured from the school in the form of a case history of each child. Also, the school supplied information with respect to the following: the grade finished in school by the mother and father; the language spoken in the home; the estimated learning ability of each parent in terms of above average,

average, below average; and the placement of siblings in regular classrooms, special classrooms, or institutions. The second type of information was a rating by the examining physician. Upon completing the medical examination, the physician checked the child in one of the four categories: etiology is probably hereditary, etiology is probably organic, etiology is probably a combination of organic and hereditary, etiology is unclassified. The third type of information was a rating by the examining psychologist. In both 1957-1958 and 1958-1959 the examining psychologist checked the child on the same four ratings as did the examining physician.

Examination of all the information revealed many inconsistencies. There was considerable inconsistency from one year to the next in the psychologists' ratings. Also, considerable discrepancy was found between the psychologists' and the physicians' ratings; the examining physician placed most children in the unclassified group. To have inferred that if the parents were of average ability and average educational attainment, the child should be classified organic was deemed unreliable; similarly, to have inferred no organic difficulty if parents and siblings of the child were found to be of low intelligence and of low educational attainment would have been unwise since injuries can and do occur in these families. Difficulty in classifying children according to etiology is well documented in the literature with disagreement as to how accurately children of IQ below 70 in institutions can be classified using the best neurological services. Inasmuch as many low IQ children in the present study had IQs above 70, it is entirely possible that impoverished environment rather then mental retardation in the parents or damage to the central nervous system may have resulted in their apparent mental retardation. Finally, it is possible for parents of average intelligence to produce low IQ children in whom no organic difficulties can be found.

Though the investigators were unable to classify the children as they had originally intended, it is not believed that this constitutes a serious handicap to the study. Both Gallagher (1957) and Capobianco (1954) have conducted significant research in the attempt to ascertain differences among exogenous and endogenous retardates. Gallagher found no significant difference between brain injured mentally retarded children and familial mentally retarded children on tasks involving perceptual ability, direct and incidental learning aptitude, quantitative concepts, and successes and failures on items of the Binet test. He found a difference in language development; however, one of the differences favored the brain injured, while the other favored the familial retarded. He also found the brain injured children, compared to the familial, to be more hyperactive, lacking attention, being fearful, less popular, and generally more uninhibited. He concluded that the brain injured children should not be treated as a homogeneous group educationally and that information of a neurological type showed that many brain injured children did not have unfavorable characteristics that might be assigned to them as a group. Capobianco found no difference in arithmetic achievement of endogenous and exogenous type mentally retarded children.

In summary, the information implies three groups of children who might be regarded as typical of children of their intelligence in communities of similar size, prosperity, and cultural conditions. The low IQ or mentally retarded children were classified as educable, and, although enrolled in special classes, were generally indistinguishable in physique and general appearance from the average and high IQ children enrolled in regular classrooms. Though their dental health was not as good as that of the average and the high IQ, their physical health was about as good as was their psychological health. Eighty-five per cent of the fathers of the high IQ children were in professional, semiprofessional, or managerial and official occupations; whereas 80 per cent of the fathers of the low IQ were in unskilled, semiskilled, skilled labor, and service occupations.

III DESCRIPTION OF THE MEASURES

Seven types of measures were secured on the children in each year 1957-58 and 1958-59, and part of them were secured in 1956-57 in the pilot study, but the latter are not included in this discussion. The measures and the order in which they will be discussed are as follows:

1. Arithmetic learning-retention tasks -- counting, common problem-solving with pennies, addition, subtraction, differentiated problem-solving with change-making.
2. Physical measures -- height, weight, strength of grip, dentition, and carpal age.
3. Mental measure -- IQ as determined by the Wechsler Intelligence Scale for Children.
4. Achievement measures -- reading, arithmetic, and language.
5. Personality measures -- psychologists' ratings of emotional adjustment, achievement in relation to capacity, integration of self-concept, expression of emotion, behavior pattern, and the child's estimate of his own abilities.
6. Coordination -- handwriting speed in number of letters per minute on a five-minute test.
7. Peer acceptance -- ascertained by sociometric testing.

The last two measures were secured only for the year 1958-1959, and the timetable for securing these measures is reported later in this section.

ARITHMETIC LEARNING-RETENTION TASKS

Five arithmetic learning-retention tasks were developed and administered to test Hypotheses 1 and 2 regarding efficiency of acquisition and retention. The general sequence in developing each task was to survey general curriculum materials, research materials, and the curriculum guides of the Madison Public Schools. After this research had been completed, each task was set up in tentative form. This form was then administered to a small number of children not in the experiment. Following this administration, the researchers made changes as deemed appropriate. The final form was then constructed. This final form and instructions related to its administration were then tried out in the Learning

Laboratory of the Department of Education. The entire research team participated in this phase in order that the instructions were reasonably well standardized for those who administered the task and also for scoring purposes. Subsequently the research team met to clarify any problems being experienced. Each task is now treated in further detail.

The Counting Task

Table 5 shows the salient features of each task so far as the survey-acquisition-rest-retention sequence is concerned. In the administration of the counting task, the examiner first conducted a survey to ascertain the child's present achievement level in counting. In this survey, the level at which the child made two consecutive errors in counting, or after encouragement stated he could go no further, became his learning task. Thus, if a child made two consecutive errors, for example, 7-13-19, his task was to learn to count by 7's from 7 through 77. (Appendix D gives the instructions for the entire sequence related to the counting task, including the method of surveying the child's present achievement level.)

As shown in Table 5 each child was given a total of 19 minutes to learn to count 10 items at an appropriate level of difficulty. The child who did not use the entire 19 minutes to learn the 10 items used the remaining time for overlearning. Thus, in this task the children had unequal amounts of time for overlearning, but the number of items to be learned was the same for all children. The teacher-examiner reinforced about 50 per cent of the child's correct responses by saying, "That's right," "Correct," "Good," and similar terms. The teacher-examiner gave a demonstration of the process by counting aloud the sequence to be learned or by presenting it in written form. In addition, for all except the lowest performers among the low IQ, the survey task in itself provided pupils with the opportunity to count in sequence by 1's, 2's, 3's and the like. For some children the counting involved rote memory almost totally; for other children it involved some adding. For many low IQ subjects, who could not add well, to learn

TABLE 5

DESCRIPTION OF THE ARITHMETIC LEARNING TASKS

Task	Survey of Each Child to Determine Appropriate Difficulty Level	Teaching-Acquisition Conditions	5-Min. Rest Interval
Counting	Survey of the child's present achievement level in counting	All Ss used 19 min. Unequal amt. overlearning time. About 50% reinforcement. Demonstration of process. Rote memorization or adding. Score: no. of 10 items correct.	Reading of interesting children's books. Looking at pictures. Engaging S in conversation.
Common Problem-Solving	No survey	Ss used 3-20 min. One reinforcement when correct solution attained. No demonstration of process but 8 levels of help given as necessary. Score: time to solve problem.	Reading, looking at pictures, or E and S engaged in conversation.
Addition	Survey of 3 items within 18 levels of difficulty beginning at the easiest level and progressing to level of difficulty at which 2 consecutive items wrong.	4-17 min. used in teaching. E teaches and S solves each item. No overlearning. Acquisition without help from E limited to 5 min. immediately after teaching completed. 100% reinforcement. Score: No. of exercises worked correctly.	Reading, looking at pictures, or E and S engaged in conversation.
Subtraction	Survey of 3 items within 23 levels of difficulty beginning with easiest level and progressing to level of difficulty at which 2 consecutive items wrong.	Minimum time of 10 minutes, max. 20. E teaches each item, S follows with working it. 100% reinforcement. Process to solution emphasized. Score: no. of 10 items worked correctly.	Listening to tape-recorded story.
Differentiated Problem-Solving	Survey of related concepts and skills in problem-solving.	An easy problem and manner of solving it demonstrated first. Problem then presented. Time to solve between 3 and 15 min. No overlearning, one reinforcement, 3 cue levels given. Score: time to solve problem.	Listening to tape recorded story and music.

TABLE 5 (cont.)

Task	5-Min. Retention	6 or 7-Wk. Retention	12 or 14-Wk. Retention	18-Wk. Retention
Counting	Set established. No specific amount of time assigned. Two successive errors terminated the retention procedure. Score: No. of 10 items correct.	Warm-up and set incorporated. Counting by a less complex unit used in warm-up. No specific time. Two consecutive errors terminated retention procedure. Score: No. of ten items correct.	None administered	Warm-up and set incorporated. Warm-up composed of counting a less complex unit. No designated time limit. Two consecutive errors terminated retention procedure. Score: No. of 10 items correct.
Common Problem-Solving	Directions given and Ss worked problem. 7 min. allowed for retention. Levels of help given. Score: time to solve problem.	Directions stated and Ss directed to solve. 7 min. allowed for retention. Levels of help given. Score: time to solve problem.	Directions to problem stated and Ss worked. 7 min. allowed for retention. Levels of help given. Score: time to solve problem.	
Addition	Directions identical to acquisition test. Limit of 5 min. allowed for solving 10 items. Score: no. of exercises worked correctly in 5 min.	Warm-up of 1 item from survey. No help given in retention test. Retention test limited to 5 min. Score: no. of items worked correctly.		
Subtraction	Directions identical to acquisition test. No time limit given. No help given. Score: No. of items worked correctly.	Warm-up by E working 1 item from survey. Set established. No help given in retention test. No time limit set for retention. Score: no. of items worked correctly.	Warm-up by 7-week procedure. No help given in retention test. No time limit set for retention. Score: No. of items worked correctly Set established.	
Differentiated Problem-Solving	Retention Group: Directions for problem given and same problem presented to retention group. Time to solve 3-15 min. No overlearning, one reinforcement. 3 cue levels given to those needing it. Score: time to solve problem and cue level. Transfer Group: Directions given and similar problem presented. Time to solve 3-15 min., 3 cue levels given, no overlearning, one reinforcement. Score: time to solve problem and cue level.	Retention Group: Demonstration of easy problem, directions and problem idential to acquisition given. Time to solve 3-15 min. No overlearning, one reinforcement, 3 cue levels. Score: time to solve problem and cue level. Transfer Group: Demonstrate easy problem. Directions and new but similar problem given. Time to solve 3-15 min., 3 cue levels given, no overlearning, one reinforcement. Score: time to solve problem and cue level.		

the sequence of counting by 2's from 2 to 22 was almost totally rote memory. For some high IQ children, counting by 13's, for example, there was considerable adding; that is, the child apparently said 13 then added 13 to get 26, added 13 to get 39, and so on. At the end of 19 minutes the child was asked again to count the particular sequence he had learned. The number of items correctly learned was designated as the child's acquisition score. No help or reinforcement was given to the child while securing the acquisition measure.

Immediately after the acquisition score was obtained, a 5-minute rest period commenced as shown in Table 5. During these 5 minutes, the child read interesting children's books, looked at pictures, or was engaged by the examiner in conversation if the picture or the reading material did not hold his attention.

At the end of 5 minutes the 5-minute retention measure was secured. A set was established for the child to reproduce the same 10 items in the counting sequence as he had done previously. The child was given an unlimited amount of time to recall the 10 items. When two successive errors were made he was stopped and the number of items correct was used as his 5-minute retention score. No help or reinforcement was given. After intervals of 6 weeks and 18 weeks, successive retention measures of counting were given under the same conditions as was the 5-minute retention measure.

During the 5-minute interval between securing the acquisition score and the 5-minute retention score, the time was under the complete control of the examiner. The examiner did not attempt to set any controls over the child thereafter. However the teachers of the children informed the researchers that formal instruction had not been given on the particular task between the 5-minute retention and 6-week retention measures. The same conditions existed for the other tasks--no child received formal instruction on any task between the 5-minute and 6- or 7-week retention measure.

The Common Problem-Solving Task

Different from the other four tasks graded to each child's achievement level, the common problem-solving task was the same for all children. As shown in Table 5, there was no survey for the common problem-solving task. The researchers tried out the particular problem with a small number of children, and upon finding that it was appropriate for varying levels of IQ, with appropriate help, the same task was administered to all children. Appendix E shows the problem-solving task, the level of help or cues, and the instructions for administration and scoring. The basic problem presented to each child, with appropriate variation in terminology for the low IQ, was: "Here is a pile of pennies. I will not tell you how many, but suppose you wanted to give the same number of pennies to 7 of your friends, keeping none for yourself. Divide the pile of pennies so that there are the same number of pennies for each of your 7 friends. When you finish, tell me how many pennies each of your friends will get. Do you understand what you are to do?" Time to complete the problem after the question was asked was used as the measure of acquisition. Any child who needed help was given such help at specified time intervals during the teaching-learning process.

As shown in Table 5 under Teaching-Acquisition Conditions, the children used from 3 to 20 minutes, the maximum allowable, in arriving at a solution. One reinforcement was given when the correct solution was attained. However, if an incorrect solution was offered at any point, the examiner told the child that it was incorrect. No demonstration of the process was given except that the cues at prearranged time intervals involved demonstration of a step toward the solution of the problem. The acquisition score was the time the child used to solve the problem. Immediately upon solution of the problem, the 5-minute rest interval began, comprised of the child's looking at pictures or being engaged by the teacher-examiner in conversation.

At the end of 5 minutes, the same instructions were given for the child to solve the identical problem as before. Seven minutes were allowed to complete the solution. Cues of helps were given so that each child finished in 7 minutes. The score for the 5-minute retention measure was time to perform the problem to the nearest second. It should be noted that time to relearn is the basic measure here and that it is used as an indirect measure of retention. The 6- and 12-week retention measures were secured under identical conditions as the 5-minute retention measure.

The cues were given to each child as necessary in order that there would be acquisition of the task. Had a child not reached a solution, there could have been no measure of retention.

The Addition Task

A survey test was given to each child in order to find out his present achievement level in addition. When the child made two consecutive errors or after encouragement stated he could go no further, the level at which these errors were made was designated as his task level. At this level he was taught to perform 10 items correctly. (Appendix F contains instructions and related forms for the addition task including the survey.)

As shown in Table 5, the teaching-acquisition time was limited to 17 minutes. The examiner-teacher first presented and worked the item with the child directed to notice the examiner's work. The child was then asked to solve the item without looking at the examiner's solution. The presentation to the child was intended to help him gain maximum understanding of the process within the limits of efficient performance of the items. Every correct response was reinforced immediately with a term such as, "That's right," "Correct," "Good," and the like. Further, any incorrect response was immediately identified by the examiner, and help as necessary was given for the child to get the item correct. The rate of presentation was so managed that the subject was required to achieve a correct solution to each item once and only once. A child who required less than 17 minutes to finish simply stopped at that point. Thus, in the addition task, different from the counting task, there was no overlearning, and children used unequal amounts of time to learn.

As soon as the child finished the tenth item, the acquisition test was given.

No help was given to the child, and a 5-minute limit was placed upon him to complete the acquisition test. The number of items correct was designated as the acquisition score.

Immediately after the acquisition test, the child read, looked at pictures, or was engaged in conversation for 5 minutes. After this 5-minute rest interval the 5-minute retention measure was secured. The items were identical to the acquisition test. The same limit of 5 minutes was allowed for solving the 10 items and the number of exercises worked correctly was designated as the 5-minute retention score. The 6-week retention measure followed identical procedures as the 5-minute, except a warm-up of one item from the survey test was presented to the child.

The Subtraction Task

The subtraction task was the first task administered in 1958-1959. As shown in Table 5, the sequence of survey, teaching-acquisition conditions, 5-minute rest interval, 5-minute retention, 7-week retention, and 14-week retention was nearly identical to that of the addition task, the last task administered in 1957-1958. Therefore, brief attention is given to each step in the sequence at this point.

The survey procedure was of the same form as in the addition task in that a level of difficulty appropriate for each child was found. In the subtraction task the teacher-examiner presented the 10 items according to a specified time sequence by which each child was required to spend at least 10 minutes learning the 10 items and no child was permitted over 20 minutes to learn. In the subtraction task no time limit was placed upon the child's performing the acquisition test. A 5-minute limit was imposed in the addition task. In the subtraction task during the 5-minute rest interval the child listened to a tape-recorded story. The 5-minute retention measure in subtraction was secured in the same way as the 5-minute retention measure in addition with the exception that no time limit was placed on the child to complete the retention measure. The schedule for securing subsequent retention measures in 1958-1959 was a 7-week rather than a 6-week interval as had been used in 1957-1958. (Appendix G shows the subtraction task and the instructions for administering and scoring.)

The Differentiated Problem-Solving Task

The differentiated problem-solving task was set up within three difficulty ranges: one for the low IQ children, one for the average IQ children and lower performing high IQ children, and one for the higher performing average IQ children and the higher performing high IQ children. These levels of difficulty were determined by pre-testing four classrooms of children not in the study and a small group of low IQ children not in the study. Further, a survey test of concepts and skills related to problem-solving was administered to ascertain, particularly for low IQ children, which problem within their level of difficulty might be most appropriate. (The problem-solving tasks, the levels of help, and the instructions for administering and scoring are shown in Appendix H.)

In the teaching-acquisition period an easy problem and the method for reporting the solution was demonstrated first. Then the problem itself was presented to the child with directions for presenting or writing the solution but no hint of the solution given. The examiner then asked the child to state the problem, and the time measurement started at this point before the child answered. Time to solve the problem was used as the measure of acquisition. Performance time could vary from 3 to 15 minutes. If a child solved a problem in less than 3 minutes, a more difficult problem was presented according to a prearranged level of difficulty schedule. No overlearning was permitted, and there was one reinforcement of the correct solution. However, if a child presented an incorrect solution, he was told that it was incorrect. To make certain that each child performed the problem correctly once, levels of help or cues were given at specified 3-minute intervals, the last one being a demonstration of the solution of the problem. In this differentiated problem-solving, then, time to learn was allowed to vary and the criterion was one correct performance. As soon as the problem was solved, the 5-minute rest interval started. The child listened to a tape recorded story and musical selection during this rest interval.

As noted in Table 5, a departure from the retention design for the previous task was made with the differentiated problem-solving task. The 120 children were randomly divided into two groups, one designated a retention group and the other, a transfer group. Thus, 30 boys and 30 girls, 10 from each IQ level, were randoml drawn and assigned a transfer problem. The remaining 30 boys and 30 girls were assigned retention problems identical to the one presented to them during the teaching-learning period. For the 5-minute retention measure, then, the 60 children designated retention subjects received the identical problems that they had originally acquired, whereas the 60 children designated the transfer group were given different problems but of the same type and level of difficulty as they had acquired during the teaching-learning sequence. The instructions for securing the 5-minute retention measure were identical to those for securing the measure of acquisition. Similarly, for the 7-week retention measure the retention group solved the same problem for the third time whereas the transfer group was given the third new problem. The 5-minute measure of retention and of the applied measure of retention, transfer, and the 7-week measures were secured under the same conditions as the acquisition measure except that a warm-up was given for the 7-week measure. This warm-up consisted of the examiner demonstrating one easy problem to each child of low IQ, and one easy problem different from the one used for the low IQ, to each child of average and high IQ.

It will be noted that three retention measures were secured for certain tasks. As will be shown subsequently in Table 7, the general procedure was to start in the first semester with the administration of one task to secure the acquisition and 5-minute retention measures on it. Subsequently, when the teacher-examiners returned, they first secured the 6- or 7-week measure of retention of the first task and then presented the new teaching-learning task and secured the acquisition and 5-minute retention measure on it. In 1957-1958 the teacher-examiners worked with each child on four different occasions, thus permitting an 18-week measure of retention of the first task, a 12-week measure for the second task, and a 6-week measure for the third task. In 1958-1959 7- and 14-week retention measures were possible for the subtraction task whereas only a 7-week measure was secured for the differentiated problem-solving task. It was assumed that the securing of the retention measure prior to presenting a new or second learning task would have the same effects on each of the three IQ groups and that the effects of the warm-up or interference produced by securing the retention measure would be equal among the three IQ groups.

THE PHYSICAL MEASURES

Five measures of physical development were secured on each subject, including the pilot group, in October, 1957, and again in October, 1958. These measures were: height, weight, strength of grip, dental or number of permanent teeth, and carpal age. Since the physical measures are subsequently correlated with other measures, Table 6 is now presented which describes each of the measures briefly. Interpretation of this table will be clarified in the following discussion of each of the measures.

Height

Each child was measured without shoes with a standing rule attached to a balanced beam scale. The child was told to stand tall and to look straight ahead. Height was recorded in inches to the nearest 1/8 inch. As shown in Table 6, this measure was secured in the school building, gym, or the nurses' office.

Weight

Simultaneous with the securing of height, the child was weighed in pounds to the nearest 1/8 pound. Because it was impractical to weigh all the children without clothes, since the members of the research team were of the male sex, a small sample from each grade and sex were weighed by a female assistant with all outer garments removed and then with their normal outer clothing. From these individuals, an average weight of clothing was computed. This average weight of clothing was then subtracted from each child's weight. The amount to subtract

TABLE 6

DESCRIPTION OF THE PHYSICAL, MENTAL, ACHIEVEMENT, PERSONALITY, SOCIOMETRIC, AND HANDWRITING MEASURES

Type of Measure	Instrument	Score Used	Where Secured	By Whom Secur
Height	Standard Beam Scale	Inches to nearest .1	School gym or nurse's office	Research team
Weight	Standard Beam Scale	Pounds to nearest .1	School gym or nurse's office	Research team
Grip	Smedley Hand Dynamometer	Average of 2 readings in kilograms to nearest .1	School gym or nurse's office	Research team
Dental	Dentist's count of permanent teeth	No. of permanent teeth	School classroom or nurse's office	Practicing dentist
Carpal	Carpal X-ray	Average of 2 readings in months	Hospital	Hospital staf
WISC	WISC IQ	Total IQ	School testing room	School and clinical psychologis
Reading	California 1950, Form AA Primary Form, Low IQ, Elementary, Av. & Hi.	Raw Score and months of age	School classroom	Research team
Arithmetic	California 1950, Form AA Primary Form, Low IQ, Elementary, Av. & Hi.	Raw Score and months of age	School classroom	Research team
Language	California 1950, Form AA Primary Form, Low IQ, Elementary, Av. & Hi.	Raw Score and months of age	School classroom	Research team
Emotional Adjustment	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologi
Achievement in Relation to Capacity	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologist

TABLE 6 (CONTINUED)

Type of Measure	Instrument	Score Used	Where Secured	By Whom Secured
Integration of Self-Concept	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologist
Expression of Emotion	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologist
Behavior Pattern	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologist
Child's Estimate of Own Abilities	Rorschach, 3 TAT cards, 1 figure drawing	Average of 2 ratings, 0-10	School classroom or nurse's office	School or clinical psychologist
Handwriting	5-min. Speed Test	Average no. of letters per min.	School classroom	Research team
Sociometric	5-Choice Friendship	Weighted Score	School classroom	Research team

ranged from one pound for fourth-grade girls to two pounds in 1958-1959 for fifth-grade boys.

Strength of Grip

Grip was measured in kilograms to the nearest 1/10 using the Smedley Hand Dynamometer. Each child was seated in a chair with his preferred arm resting on a table in a supine position. The dynamometer was placed in his hand, and he was given assistance in grasping the dynamometer in a prescribed manner, namely, with the lower bar resting against the base of the thumb and the upper bar against the second joint of the fingers. The child was then instructed to squeeze as hard as he could. The dynamometer was taken from his hand, and the reading was recorded.

The child was then asked to turn his hand over into a pronate position and the procedure was repeated. The final reading or third reading was taken again with the hand in a supine position.

Since there was no practical method of setting the distance between bars of the dynamometer for each child, a constant setting of 30 millimeters was used in 1957-1958 and 32 millimeters in 1958-1959.

The average of the two highest readings made by the child was used as a measure of strength. Under these conditions it was possible, regardless of the length of the hand, to utilize the best two of three measures. In some instances, the two best measures were in the supine position. In others, one was in a supine, the other in a pronate position. Thus, if there was advantage because of shortness or longness of hand for the standardized setting, it was found that such advantage would show up in the average of the two measures. The method of scoring was based upon a comparison of test-retest reliability coefficients between the average of the two highest readings secured on each child and between the highest of the three readings obtained on each child. The resulting correlations were .92 for the average of the two highest readings and .83 for the highest reading in the test-retest procedure.

Dentition

The number of permanent teeth which had erupted at least one-half through the gums was determined by a practicing dentist. A recording sheet was used to identify each tooth which was judged to be present and permanent. If a child had a tooth absent because of an hereditary anomaly or extraction but which would have been permanent had it been present, the tooth was included as a permanent tooth.

Carpal Age

An X-ray of each child's right hand was taken at University Hospital, University of Wisconsin, or at a hospital in Milwaukee. An independent reading of each X-ray was made by the same two resident radiologists at University Hospitals throughout the study. Age norms (Greulich, 1950) were used in estimating the age in months of each child. The average of the two independent readings was used as the carpal age of the child.

MENTAL MEASURE

The Wechsler Intelligence Scale for Children was used as the primary mental measure. As noted previously, it served as the basis for selecting the children and placing them into the IQ level groups. This test was administered by school or clinical psychologists according to standardized procedures in the testing room of the school. While both the verbal and performance scores were obtained, only the total IQ was used in this study.

When the research was originally planned, it was intended to use mental age in testing Hypothesis 5. However, the school systems are using the Stanford Binet less frequently and the WISC more frequently. Since the WISC was so standardized that mental age cannot be readily secured, IQ was used as the criterion rather than mental age. The age range of the children was limited to fifteen months. It was assumed that within this narrow range and with an equal distribution of C.A. according to month of birth among the three IQ groups, WISC IQ would serve as well as Stanford Binet M.A.

THE ACHIEVEMENT MEASURES

Reading, arithmetic and language achievement were measured through use of the California Achievement Battery, 1950 Form AA. The Primary Form was used with the low IQ children, the Elementary Form with the average and high IQ children. No satisfactory way of equating raw scores on the two forms was found; therefore, the raw scores for all the children were changed to months of age as outlined in the test manuals.

Certain revisions in the instructions for the administration of this test were needed for the low IQ children. The main change involved items which did not require the child to read the items or the instructions. For such items and subtests, the examiner read the instructions and the item to the child. For example, if a child could not read a written problem which involved the addition of 3 and 4, the examiner read the item and asked the child to give the answer. If the child could then not write the answer, the examiner recorded the answer given. A second variation was that the average and high IQ children tested either as total classroom groups of which they were a part or as smaller groups from the classroom. The general procedure was to administer the entire battery to the entire classroom as a group for the average and high IQ children. As necessary, the tests were administered individually to low IQ children or in small groups.

THE PERSONALITY MEASURES

Each child was seen at his own school by the examining school or clinical psychologist during regular school hours according to a prearranged schedule. The personality measurement was standardized in such manner that first the examiner went to the child's classroom and invited the teacher to release the child to him. The examiner took the child to the special room and spent a few minutes in pleasant conversation that was designed to put the child at ease and to help develop rapport.

The child was then asked to "Draw a Person" on a blank white sheet of paper. After the child completed the drawing, the examiner noted whether it was male or female and then asked the child the following questions:

(a) "How old is he (or she)?"
(b) "How smart is he (or she)?"
(c) "How does he (or she) do in school?"
(d) "What does he (or she) want to do when he (or she) grows up?"

The child was encouraged to elaborate upon his responses as much as possible.

A complete Ink Blot (Rorschach) Test was administered according to standardized procedure including an inquiry testing of the limits whenever they seemed indicated by the nature of the child's responses. All Rorschachs were scored by a standardized procedure (Hertz, 1951b).

After the Rorschach, three selected cards of the Thematic Apperception Test were presented to the child. Card 1, 3BM, and 7BM were used for the boys, and cards 1, 3BM, and 7GF were used for the girls. The child was asked to make up a story about the picture and to make his story in three parts: "What led up to this point," "What is going on now," and "How is it going to end?" When the stories were brief the child was encouraged to add to them. Sometimes direct questions were asked related to the theme he was expounding. These stories were recorded verbatim on forms prepared by the research team and the participating school and clinical psychologists.

After administration of these three projective tests, the child was questioned directly about such things as how he felt he was doing in arithmetic, reading, spelling, writing and grammar. He was also asked how smart he was, how well he did in sports and games, how well he thought other children liked him, how well he thought adults liked him, and also how often he was picked to be a leader by his classmates. These questions were couched in a language that was calculated to help the child understand the question and to help him reply in as honest a manner as was possible. The primary purpose of this questioning was to make inferences in addition to those from the projective tests concerning the six personality ratings which are now described.

After the administration of the projective tests and the completion of the clinical interview, the examiner took the materials and subsequently rated the child from 0 to 10 on each of the following: emotional adjustment from 0 to 10 with 0 being poor and 10 being excellent emotional adjustment; achievement in relation to capacity with 0 being under expectancy and 10 being above expectancy; integration of self-concept with 0 being poorly organized and 10 being well organized; expression of emotion with 0 being introverted and 10 being extroverted; pattern of behavior with 0 being withdrawn and 10 being aggressive; the child's estimate of his own abilities with 0 being underestimating and 10 being overestimating. In all of these ratings the midpoint of about 5 was intended to be approximately what one would expect if one averaged the ratings obtained. After the examining psychologist made the ratings, a second psychologist took the materials from the projective tests only and performed similar independent ratings on each of the six variables.

Prior to starting the personality assessment and the subsequent ratings, the director of the research project met with the clinical and school psychologists to tentatively agree upon what each of the ratings meant. These agreements are now reported. Emotional adjustment refers to the child's feelings and reactions to himself and others. Achievement in relation to capacity refers to the child's performances in relation to what the psychologists judged he could do. Integration of self-concept refers to the organization of the child's idea about himself, particularly, and also about himself in relation to others, with a well integrated self-concept meaning the child had fairly realistic and well organized ideas and feelings of himself. Expression of emotion refers to how the child expresses his pleasant and unpleasant feelings with a 0 rating meaning that he withholds expression of feeling, and 10 meaning he expresses his feelings freely and openly. Pattern of behavior is closely related to expression of emotion except that pattern of behavior refers to all forms of expression rather than simply pleasant and unpleasant feelings with a 0 rating meaning the child is almost mute and immobile and 10 meaning the child is very active and also tends toward high aggressiveness. The child's estimate of his own abilities refers to how this child estimates his general ability to learn; ability here refers more to what intelligence and achievement tests measure than to psychomotor ability. (The forms for recording the responses to the projective tests are presented in Appendix C.)

Handwriting

The measure of handwriting was a 5-minute speed test with the score being the average number of letters per minute which the child wrote for a 5-minute interval. The test was administered in the school classroom by the research team. (Appendix I gives the instructions and form for the handwriting test.)

The children of low intelligence were using manuscript writing except in one class. The children of average and high intelligence had changed from manuscript to cursive writing in 1957-1958. Since there was considerable variation in the instructional program in handwriting by IQ level and also among classrooms, the following instructions to secure the measure of handwriting are worth examination: "Your teacher has put a sentence on the board. When I say, 'Start,' write it as well as you can and as fast as you can until I say, 'Stop.' Use every line of the paper. Also, after you write the last word, 'Dog,' start again with 'A quick ...' on the same line. Notice how your teacher has done this on the board. Here is the sentence. Remember you are to write it as well as you can and as fast as you can until I say 'Stop.' I have more pencils and paper. If you need any, come up and get them." (The sentence was: "A quick brown fox jumpes over the lazy dog.") It should be noted that the average and high IQ children read the sentence without difficulty. They probably also could recall the entire sentence without referring to the board or to the typewritten copy on the writing sheet. Some of the low IQ children could not read the sentence well and had to refer to the board frequently.

THE SOCIOMETRIC MEASURE OF PEER ACCEPTANCE

An open-choice and a 5-choice sociometric test were administered to the children by classroom groups within a very short time span. As soon as the open choice test was completed, the 5-choice test was administered. (The instructions and forms for this test are in Appendix J.) In the open-choice test a mimeographed sheet containing the teacher's name and the name of each child in the classroom was given to each child. The child was then asked to underline the name of each classmate who was a good friend. He was instructed to underline the names of his good friends. After this was completed the 5-choice test was given. Again the child was presented a class list. He was then told to put a 1 after the name of his best friend, a 2 after his second best friend, and so on until he had put a 5 after his fifth best friend. First choices received were weighted five, second choices four, and so on. The weighted scores from the 5-choice test were used as the measure of peer acceptance.

The open-choice test had been administered in 1957-1958 but no satisfactory method was found for making the open-choice scores comparable for children in the various classrooms. In the open-choice test the number of choices received by each child was greatly dependent upon the ratio of boys to girls in the classroom and the total number of children in the classroom. Thus, since the open-choice test gave more useful results for immediate use by the classroom teacher, both the open-choice and the 5-choice test were given in close time proximity. Subsequent analysis showed the correlations to be relatively high by the two methods, and in addition, the 5-choice test permitted comparison of scores regardless of the proportion of sex in a classroom or the size of the classroom. However, since the low IQ children were enrolled in special classes for the educable mentally retarded and received as high scores by design as did the average and high IQ, no correlation was run between the sociometric scores and IQ or any other variable highly correlated with intelligence.

THE TIMETABLE FOR SECURING THE MEASURES

Table 7 shows the timetable for securing the learning-retention measures discussed earlier in this section. The sequence for the measures was counting, common problem-solving, addition, secured in 1957-1958; and subtraction, differentiated problem-solving, secured in 1958-1959. Within each year the procedure was to get the acquisition and 5-minute retention measure first. When coming back to get the 6 or 7 week measure of retention, the teacher-examiner first secured this measure and then secured the acquisition and 5-minute retention measure on the second task. Thus, Table 7 is to be interpreted as follows. In the period 11/18/57 to 1/10/58 the acquisition and 5-minute retention measure were secured in counting. Between 1/15/58 and 2/7/58 the 6-week retention measure of counting and the acquisition and 5-minute retention measure of common problem-solving were secured. Always the previous retention measure was secured first

TABLE 7

SCHEDULE OF ARITHMETIC LEARNING - RETENTION TASKS FOR 1957-58 and 1958-59

Interval Within Which Task Was Administered To First & Last Child	COUNTING	COMMON PROBLEM-SOLVING	ADDITION	SUBTRACTION	DIFFERENTIATED PROBLEM-SOLVING
11-18-57 to 1-30-58	Acq. & 5-Min. Ret.				
1-16-58 to 2-7-58	6-Wk. Ret.	Acq. & 5-Min. Ret.			
2-20-58 to 3-27-58	12-Wk. Ret.	6-Wk. Ret.	Acq. & 5-Min. Ret.		
4-21-58 to 4-28-58	18-Wk. Ret.	12-Wk. Ret.	6-Wk. Ret.		
11-3-58 to 12-16-58				Acq. & 5-Min. Ret.	
1-14-59 to 2-16-59				7-Wk. Ret.	Acq. & 5-Min Ret.
2-24-59 to 3-26-59				14-Wk. Ret.	7-Wk. Ret.

*Christmas vacation and other holidays were not counted in the interval between task administrations. The intervals were based on the number of weeks school was actually in session.

and then the acquisition and 5-minute retention measure.

Table 8 shows the time schedule for securing the other measures. It is seen that the five physical measures were secured during the month of October, 1957, and again during the month of October, 1958. Minor exceptions to this were made in 1957-1958 because of the Asiatic flu epidemic and in 1958-1959 because of pupil absenteeism for other reasons. In 1957-1958 the WISC IQ was obtained from 10/1/57 to 12/18/58 and 1958-1959 from 10/6/58 to 2/16/59. The achievement measures were secured in the same time interval as the physical measures. The personality assessment was done from 11/2/57 to 3/25/58 during the first year and from 1/1/58 to 4/27/59 the second year. It was assumed that the IQ score and the ratings

TABLE 8

SCHEDULE · FOR SECURING PHYSICAL, MENTAL, ACHIEVEMENT, PERSONALITY, SOCIOMETRIC, AND HANDWRITING MEASURES

TYPE OF MEASURE	DATE SECURED
Height	October, 1957 October, 1958
Weight	October, 1957 October, 1958
Grip	October, 1957 October, 1958
Dental	October, 1957 October, 1958
Carpal	October, 1957 October, 1958
WISC	10-1-57 to 12-18-58 10-6-58 to 2-16-59
Reading	October, 1957 October, 1958
Arithmetic	October, 1957 October, 1958
Language	October, 1957 October, 1958
Emotional Adjustment	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Achievement in Relation to Capacity	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Integration of Self-concept	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Expression of Emotion	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Behavior Pattern	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Child's Estimate of own ability	11-2-57 to 3-25-58 11-11-58 to 4-27-59
Handwriting	2-24-59 to 3-24-59
Sociometric	2-24-59 to 3-24-59

were fairly stable and would not change markedly from one month to another. In case changes occurred it was assumed that such changes would be distributed equally among the three IQ groups.

The handwriting and sociometric measures were secured in the period 2/24/59 to 3/24/59. The sociometric tests were administered prior to the handwriting. The rationale for this sequence was that in case a child might have wished to discuss with other children or with the examiner his particular choices, the handwriting test immediately following would divert his attention from the sociometric test.

RELIABILITY AND VALIDITY OF THE MEASURES

Reliability and validity of the measures is especially important in this study. Now follows a discussion of the reliability and validity of the measures.

Reliability

Table 9 shows the reliability coefficients for 20 measures. The two measures for which reliability coefficients were not secured, and are therefore not reported in Table 9, are number of permanent teeth and handwriting speed.

The correlations ranging between .73 and .89 for the five arithmetic learning tasks are an inferential type of information concerning reliability. These correlations are based on the acquisition and the 5-minute retention scores for the entire group of 120 subjects. While the relatively high correlations in themselves are not a direct measure of reliability, one infers that had the test and scoring system been completely unreliable, one would have secured zero order correlation. Since the high correlations were obtained, one infers that there was relatively high reliability of the measuring and scoring procedure for the five arithmetic learning-retention tasks.

The correlations of .90-.99 for the measures of height, weight, grip, and carpal suggests that these measures are highly reliable. Number of permanent teeth was checked for reliability in the following manner. The dentist indicated which tooth was permanent in 1957-1958. Without knowing which tooth had been counted as permanent in 1957-1958 he again indicated the permanent teeth in 1958-1959. A subsequent test by the research team indicated that the dentist had not called any tooth not permanent in 1958-1959 which he had designated as permanent in 1957-1958.

The reliabilities of the WISC IQ and the California Achievement Test have been reported in the manuals for the tests. As shown in Table 9 the reliability coefficients reported in the manuals ranged from .91 to .95.

Table 9 shows that the reliability coefficients for the six personality variables are considerably lower than for any other variables. Further, it is seen

TABLE 9

RELIABILITY COEFFICIENTS OF TWENTY MEASURES

MEASURE	BASIS OF CORRELATION	GROUP	YEAR	CORRELATION
Counting	Acq.-5M Ret.	Entire 120S's	1957-58	.79
Common Problem-Solving	Acq.-5M Ret.	Entire 120S's	1957-58	.58
Addition	Acq.-5M Ret.	Entire 120S's	1957-58	.89
Subtraction	Acq.-5M Ret.	Entire 120S's	1957-58	.74
Differentiated Problem Solving	Acq.-5M Ret.	Entire 120S's	1957-58	.73
Height	Test-Retest	25 Boys	1957-58	.98
	Test-Retest	25 Girls	1957-58	.99
Weight	Test-Retest	25 Boys	1957-58	.99
	Test-Retest	25 Girls	1957-58	.99
Grip	Test-Retest	25 Boys	1957-58	.90
	Test-Retest	25 Girls	1957-58	.98
Carpal	Ind.Readings	120 Boys & Girls	1955-56	.90
WISC IQ	Published Manual,	Full Score, Age 9½		.95
Reading Achievement	Published Manual	(Primary Battery)		.92
		(Elementary Battery)		.93
Aritihmetic Achievement	Published Manual	(Primary Battery)		.92
		(Elementary Battery)		.95
Language Achievement	Published Manual	(Primary Battery)		.91
		(Elementary Battery)		.95
Emotional Adjustment	Ind.Ratings	105 Boys & Girls	1957-58	.77
		Entire 120S's	1958-59	.41
Achievement in Relation to Capacity	Ind.Ratings	105 Boys & Girls	1957-58	.53
		Entire 120S's	1958-59	.42
Integration of Self-Concept	Ind.Ratings	105 Boys & Girls	1957-58	.68
		Entire 120S's	1958-59	.51
Expression of Emotion	Ind.Ratings	105 Boys & Girls	1957-58	.68
		Entire 120S's	1958-59	-.03
Behavior Pattern	Ind.Ratings	105 Boys & Girls	1957-58	.67
		Entire 120S's	1958-59	.33
Child's Estimate of own abilities	Ind.Ratings	105 Boys & Girls	1957-58	.41
		Entire 120S's	1958-59	.15
Sociometric Scores	Test-Retest	4 Classes of Low IQ	1958-59	.69
		4 Classes of Av. and High IQ	1958-59	.79

that the correlations are considerably lower for 1958-1959 than they were for 1957-1958. In 1957-1958 the range was from .41 to .77 whereas in 1958-1959 the range was from -.03 to .51. The general pattern of lower correlations for 1958-1959 may have resulted from the psychologists' not discussing the ratings of a small sample of children who were tested early in 1958-1959 as they did in 1957-1958. The large difference between the correlations related to expression of emotion cannot be accounted for at this time. While the reliabilities of the two independent ratings are not so high as desired, especially in 1958-59, they were accepted as the best measures obtainable. It will be recalled that the average of the two independent ratings was used.

An open-choice sociometric test was given to the children by classroom groups. This was followed immediately by a 5-choice test. For four classes of low intelligence the test-retest correlation obtained was .69 and for four classes in which children of average and high intelligence were enrolled, the correlation was .79.

Validity

A high degree of face validity is inherent in the five arithmetic learning-retention tasks. In counting, addition, and subtraction the child's task was to count, to add, or to subtract. Generally, in the common problem-solving task and in the differentiated problem-solving task the child was asked to solve a problem. Both were problems in the sense that the child had no immediately available responses for their solution, expended effort toward the solution, and eventually reached a solution. A high degree of ego-involvement was observed in the differentiated problem-solving task. Some children became quite upset when they could not achieve a solution, and the teacher-examiner remained silent, giving no help or offering any encouragement until the specified time interval for offering help arrived.

The validity of the physical measures is also quite obvious. Each of the measures is a direct measure and is generally accepted as such. In a subsequent table the correlations among these measures and the remainder of the measures used in the study are given. From these correlations inferences can be made concerning the predictive properties of the physical measures.

Many published reports have appeared on the validity of the Wechsler Intelligence Scale for Children. The WISC has been reported as a good predictor of achievement in academic subjects. In a later table, correlations ranging from .80 to .95 are reported between WISC IQ and reading, arithmetic, and language achievement. High face validity for the three achievement tests is also reported (California Test Bureau, 1951). In terms of widespread use of these tests it is apparent that the users assume reasonably high validity between the test scores and the objectives of instruction. (This is not to be interpreted that other achievement tests might not have equally high or higher validity.)

Many reports have appeared concerning validity of the Rorschach Test, the Thematic Apperception Test, Draw-A-Man Test. The evidence is somewhat conflictin with respect to general validity of projective tests. Since the personality ratings are based upon materials secured from these tests and a short clinical interview, one cannot state and prove the validity or lack of validity of the ratings. The researchers simply used this procedure of testing and rating as being the best one currently available, and accepted the results of experienced psychologists in rating children on these variables in the same manner as they accepted the judgment of the physicians who rated the child's general health as shown previously. With the low reliability as reported above on one of the variables and with no empirical test of validity, the researchers would not accept the ratings as a basis for predicting subsequent behavior of individual children.

The validity of sociometric test results is about as difficult to ascertain as is that for personality ratings such as just reported. The point of view expressed by Pepinsky (1949) was accepted in this research, namely, that the 5-choice test is a valid measure of peer acceptance at a point in time in the life of children.

IV RESULTS

This section of the report gives the results of the study in terms of the testing of five hypotheses and a subsequent purpose.

1. Speed of acquiring arithmetic learning is inversely related to retention among groups of children of low intelligence (IQ 55 to 80), average intelligence (IQ 90 to 110), and high intelligence (IQ 120+).

2. Retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level.

3. Uneven physical development within the child accompanies low achievement in arithmetic and in reading.

4. A low level of physical development within the child accompanies low achievement in arithmetic and in reading.

5. The within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithmetic achievement is the same among children of low, average, and high intelligence. A truncated hypothesis is that the within-child variability in reading achievement, language achievement, and arithmetic achievement is the same among children of low, average, and high intelligence.

6. The other main purpose of the investigation was to ascertain the relationships among the physical, achievement, and personality measures and the differences among the three IQ groups in each measure.

Each of the above hypotheses in abbreviated form serves as a heading in the remainder of this section. Since the method of securing the measures, the times for securing the measures, and their reliability and validity have been previously discussed, infrequent mention of these matters will be made in reporting the results.

HYPOTHESIS 1: INVERSE RELATIONSHIP BETWEEN ACQUISITION AND RETENTION

This hypothesis suggests that the high IQ children learn rapidly and also forget rapidly, the low IQ children learn slowly and forget slowly, the average IQ learn and forget at a moderate rate. Substantiation of the hypothesis, therefore, implies a higher ratio score between learning and relearning for the low IQ children than for the high IQ children. Differences among means should be significant at the .01 level to support the hypothesis.

A common problem-solving task was arranged to test the hypothesis and the ratio scores between time to learn and time to relearn at 5-minute, 6-week, and 12-week intervals were computed for each child and used in the analysis of variance.

Table 10 shows the distribution of learning scores in seconds. Casual inspection of the table shows that the low IQ children used more time to solve the problem than did the average and high IQ. There is, however, some overlap among all three IQ groups and large overlap between the average and high IQ children. Sixteen average IQ boys and girls used less than 151 seconds to solve the problem, whereas 20 high IQ boys and girls used less than 151 seconds to achieve a solution. No low IQ child achieved a solution in less than 151 seconds.

Helps or cues were given at specified time intervals to enable each child to achieve a solution of the problem. The means, modes, and ranges for level of help according to IQ groups and sex are shown in Table 11. To acquire a solution of the problem the mean number of cues received by the low IQ boys was 1.2, the low IQ girls 1.3, the average IQ boys and girls .1, the high IQ boys .15, the high IQ girls .05. Most average and high IQ children received no help in acquisition of the problem. Similarly, in relearning after five minutes, six weeks, and twelve weeks, the low IQ group received considerably more help than did the average and high groups. Though helps were given, the test of the hypothesis was made ignoring them. No way was found for changing levels of help into time in seconds; in addition, the help was provided as needed in the relearning measures. Since the relearning measures had to be secufed to test the hypothesis, it was deemed essential to have the low IQ children, as other children, achieve a solution the first time and with help, if necessary.

TABLE 10

DISTRIBUTION OF THE ACQUISITION SCORES IN COMMON PROBLEM-SOLVING

Time* (Seconds)	Low IQ Boys	Low IQ Girls	Average IQ Boys	Average IQ Girls	High IQ Boys	High IQ Girls
0- 50						
51- 100			1		5	4
101- 150			5	10	5	6
151- 200	1	1	7	3	1	7
201- 250		1	2	2		
251- 300			1	1		1
301- 350		1	1	1	1	
351- 400		1	1		3	
401- 450		2		1	2	1
451 -500	2	2	2	1	1	
501- 550	2	2		1		
551- 600	3	3			2	1
601- 650	1	3				
651- 700	2					
701- 750	1					
751- 800	1	1				
801- 850	2					
851- 900						
901- 950	1	2				
951-1000	1	1				
1001-1050	1					
1051-1100						
1101-1150						

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*In the problem-solving task all children were required to perform the same common task: to divide a pile of pennies of unknown quantity (to S) among a given number of friends and to state the number of pennies each friend would receive. The table gives the number of children who learned the task within the particular time range.

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TABLE 11

MEANS, MODES, AND RANGES FOR LEVELS OF HELP IN COMMON PROBLEM-SOLVING

	Learning Level of Help			5-Min. Relearning Level of Help			6-Wk. Relearning Level of Help			12-Wk. Relearning Lev. of Help		
	Mean	Mode	Range	Mean	Mode	Range	Mean	Mode	Range	Mean	Mode	Range
Low IQ Boys	1.2	1	0-3	.40	0	0-2	1.3	0	0-5	2.95	4	0-6
Low IQ Girls	1.3	1	0-4	.80	0	0-3	1.25	1	0-5	3.05	4	0-6
Av. IQ Boys	.10	0	0-1	.00	0	0-0	.00	0	0-1	.00	0	0-0
Av. IQ Girls	.10	0	0-1	.00	0	0-0	.00	0	0-0	.20	0	0-4
High IQ Boys	.15	0	0-1	.00	0	0-0	.00	0	0-0	.15	0	0-3
High IQ Girls	.05	0	0-1	.05	0	0-1	.00	0	0-0	.20	0	0-4

Table 12 shows the mean and standard deviations for the acquisition and retention measures in common problem-solving. In time-to-learn the girls in each IQ group showed lower mean scores than the boys, and the means for the 60 boys and girls were 418 and 318 seconds, respectively. Similarly, the average and high IQ children showed considerable superiority over the low IQ children with the low IQ children requiring 631 seconds to achieve a solution, and the average and high IQ children requiring 235.2 and 237.8 seconds, respectively. In the subsequent relearning trials, performance for the total group markedly improved after five minutes, deteriorated somewhat after six weeks, and in turn improved after twelve weeks.

Table 13 reports the results of the analysis of variance for the ratio scores between the learning and 5-minute relearning times in common problem-solving. The F's are small, ranging from 1.01 to 1.95. No F is significant at the .05 level, including for IQ levels, therefore, the hypothesis is rejected.

Table 14 shows the results of the analysis of variance for the ratio scores between acquisition and 6-week relearning times in common problem-solving. It is seen that the F's for sex, 3.87, and for IQ level, 2.43 are not significant at the .05 level. Therefore, the hypothesis is also rejected when tested between acquisition and 6-week relearning times.

A further test was made of the ratio of acquisition to 12-week relearning time. The same results were obtained and are therefore not reported in table form.

In summary of the three tests, Hypothesis 1 is rejected. Speed of acquiring arithmetic learning is not inversely related to retention among groups of children of low, average, and high intelligence. The ratio between learning-relearning time is the same among children of low, average, and high intelligence.

TABLE 12

MEANS AND STANDARD DEVIATIONS FOR THE ACQUISITION AND RELEARNING MEASURES IN COMMON PROBLEM-SOLVING

	Learning Secs.		5MIN. Relearning Secs.		6-Wk.Relearning Secs.		12-Wk. Relearning Secs.	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
20 Low IQ M.	703.50	234.30	307.05	140.19	314.20	102.92	265.30	106.96
20 Low IQ F.	558.50	213.10	287.25	110.06	328.75	123.82	289.55	117.50
20 Av. IQ M.	257.00	188.10	124.10	58.80	141.65	66.57	118.90	46.57
20 Av. IQ F.	213.50	125.30	108.40	57.10	154.05	72.30	109.15	51.35
20 High IQ M.	293.50	204.20	78.00	27.69	124.25	72.38	107.40	66.14
20 High IQ F.	182.00	115.80	98.95	71.44	153.55	96.75	102.10	49.07
40 Low IQ	631.00	235.40	297.15	126.42	321.48	114.08	277.42	113.00
40 Av. IQ	235.20	161.20	116.25	58.48	147.85	69.77	114.02	49.25
40 High IQ	237.80	175.20	88.48	55.17	138.90	86.69	104.75	58.29
60 M.	418.00	291.50	169.72	133.21	193.37	118.74	163.87	105.65
60 F.	318.00	232.20	164.87	119.70	212.12	129.52	166.93	117.51
120 Subjects	368.00	268.30	167.29	133.01	202.74	124.62	165.40	111.75

TABLE 13

ANALYSIS OF VARIANCE FOR THE RATIO SCORES BETWEEN ACQUISITION AND FIVE-MINUTE RELEARNING IN COMMON PROBLEM-SOLVING

Source of Variation	Sum of Squares	DF	Mean Square Deviation	F*
Sex	22,496	1	22,496	1.01
IQ Level	46,013	2	23,007	1.03
Sex by IQ	87,212	2	43,606	1.95
Error	2,543,470	114	22,311	
Total	2,699,191			

* For significance at the .01 level, the F for sex must equal or exceed 6.87, for the .05 level, 3.93. For significance at the .01 level, the Fs for IQ level and sex by IQ must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 14

ANALYSIS OF VARIANCE FOR THE RATIO SCORES BETWEEN ACQUISITION AND SIX-WEEK RELEARNING IN COMMON PROBLEM-SOLVING

Source of Variation	Sum of Squares	DF	Mean Square Deviation	F*
Sex	42,336	1	42,336	3.87
IQ level	53,197	2	26,599	2.43
Sex by IQ	21,677	2	10,839	0.99
Error	1,247,468	114	10,943	
Total	1,364,678			

* For significance at the .01 level, the F for sex must equal or exceed 6.87, for the .05 level, 3.93.
For significance at the .01 level, the Fs for IQ level and sex by IQ must equal or exceed 4.80, for the .05 level, 3.08.

HYPOTHESIS 2: RETENTION OF GRADED ARITHMETIC LEARNING

Hypothesis 2 states that retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level. This hypothesis proposes that if an arithmetic learning task is appropriately graded to the present achievement level of each child, there will be no differences in retention among the three groups. Tests of the hypothesis were made with learning retention task in counting, addition, subtraction, and differentiated problem-solving. Number of items correct was used in the acquisition and retention measures in counting, addition, and subtraction, while time in seconds was used in the differentiated problem-solving task.

Counting

Table 15 shows the distribution of the task levels in counting for the 120 boys and girls divided according to IQ level and sex groups. It is seen that no low IQ child proceeded beyond counting by 3's. The range for the average IQ boys and girls was from counting by 3's to counting by 16's. The high IQ boys and girls ranged from counting by 3's to 23's. In the counting task, boys showed superiority over girls except in the low IQ group. Also, counting was at a higher level for each successive IQ group from low to high; as demonstrated by the mean levels of 2.1, 8.6, and 14.5 for low, average, and high IQ boys, respectively.

Table 16 shows the scores, number of items correct from 0-10, for acquisition, 5-minute retention, 6-week retention, and 18-week retention. The low IQ children had a lower mean acquisition score, 7.55, than either the average, 9.52, or high IQ children, 9.65. The difference between the average and high IQ children was small, .13. The mean score is slightly higher for girls, 9.03, than for boys, 8.78. The 5-minute retention mean scores shows a similar pattern as that in the acquisition.

TABLE 15

DISTRIBUTION OF TASK LEVELS IN COUNTING

Task Level* (Counting by)	Low IQ		Average IQ		High IQ	
	Boys	Girls	Boys	Girls	Boys	Girls
by 1's	2	1				
by 2's	14	15				
by 3's	4	4	1	4		1
by 4's				2	2	
by 6's			5	4	2	
by 7's			6	3		4
by 8's				2	2	1
by 9's			2		1	3
by 11's						
by 12's			3	4	4	2
by 13's			2	1	5	5
by 14's					1	
by 15's			1			1
by 16's			1			1
by 17's					2	2
by 18's						
by 19's						1
by 23's					1	
Mean	2.1	2.2	8.6	7.1	14.5	11.7

*The task level indicates a new level of learning for the child which was next in order of difficulty above a counting task which the child could perform satisfactorily. Thus, the task level is one level above the child's counting skill at the time of testing. The table gives the number of children who were at each task level.

Table 17 shows the correlations between acquisition and 5-minute retention and acquisition and 6-week retention scores by IQ groups and for the total 120 subjects. The correlations between first acquisition and 5-minute retention were high for each IQ group, .76, for low IQ, .66 for average IQ, and .63 for high IQ children. For all subjects the correlation was .79 between acquisition and 5-minute retention. The correlations, as anticipated, were lower between first acquisition and 6-week retention, ranging from .23 to .39 for the three IQ groups. With the relatively high correlation between first acquisition and

TABLE 18

MEANS AND STANDARD DEVIATIONS FOR THE ACQUISITION AND RETENTION SCORES IN COUNTING

	Acquisition		5-Min. Ret.		6-Wk. Ret		18-Wk. Ret.	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
20 Low IQ M.	7.25	2.57	7.55	2.67	4.85	2.87	5.70	3.70
20 Low IQ F.	7.85	2.46	7.15	3.09	5.70	3.27	5.40	3.56
20 Av. IQ M.	9.50	1.36	9.40	1.39	6.20	3.25	8.20	2.25
20 Av. IQ F.	9.55	1.32	9.60	.80	8.00	2.17	8.10	2.45
20 High IQ M.	9.60	1.16	9.60	.80	8.85	2.46	8.90	2.32
20 High IQ F.	9.70	.64	9.70	.64	7.10	2.79	7.60	3.25
40 Low IQ	7.55	2.53	7.35	2.90	5.28	3.11	5.55	3.63
40 Av. IQ	9.52	1.34	9.50	1.14	7.10	2.90	8.15	2.35
40 High IQ	9.65	.94	9.65	.73	7.98	2.77	8.25	2.90
60 Boys	8.78	2.10	8.85	2.02	6.63	3.32	7.60	3.15
60 Girls	9.03	1.85	8.82	2.22	6.93	2.94	7.03	3.33
120 Subjects	8.91	1.99	8.83	2.12	6.78	3.14	7.32	3.26

5-minute retention, and also with the average and high IQ groups showing distinctly higher acquisition scores than the low IQ group, analysis of covarianc was run to test the hypothesis.

TABLE 17

CORRELATIONS BETWEEN ACQUISITION AND RETENTION SCORES IN COUNTING

IQ Group	r 1st Acq.& 5-Min. Ret.	r 1st Acq. & 6-Week Ret.
Low IQ	.76	.39
Average IQ	.66	.23
High IQ	.63	.29
All Subjects	.79	.42

Tables 18 and 19 give the results of the analysis of variance and subsequent Tukey test for the acquisition scores. The F of 17.62 in Table 18 is significant beyond the .01 level; the differences among the IQ groups in acquisition is highly significant.

Table 19 shows the results of the Tukey Tests. The difference between the low and average IQ children of 1.97 and the difference between the low and high IQ children of 2.10 are significant beyond the .01 level; the difference between the average and high IQ children of .13 is not significant.

Though the counting task was intended to be graded to each child's present achievement level, the tests reported above reveal the task was more difficult for low IQ children than for average and high IQ children but equally difficult for the average and high IQ children. While the level assigned to each child, i.e., counting by 1's, 3's, 13's and the like, may have been appropriate for each child, learning to count 10 items within the assigned level was in fact more difficult for the low IQ children than for the average and high IQ children. The task was satisfactorily graded for the average and high IQ children.

TABLE 18

ANALYSIS OF VARIANCE FOR THE ACQUISITION SCORES IN COUNTING

Source of Variation	Sum of Squares	D.F.	Mean Square Deviation	F*
Sex	1.88	1	1.88	.60
IQ Level	111.01	2	55.50	17.62
Sex by IQ	1.85	2	0.92	0.29
Error	359.25	114	3.15	
Total	473.99			

*For significance at the .01 level, the F for sex must equal or exceed 6.87, for the .05 level, 3.92.
For significance at the .01 level, the Fs for IQ level and sex by IQ must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 19

ANALYSIS OF SPECIFIC MEAN DIFFERENCES FOR THE ACQUISITION SCORES IN COUNTING*

IQ	$\bar{X}$	$\bar{X}$-7.55	$\bar{X}$-9.52
High	9.65	2.10	.13
Average	9.52	1.97	
Low	7.55		

*For significance at the .01 level, the difference must equal or exceed 1.18.

Table 20 shows the results of the analysis of covariance for acquisition and 5-minute retention scores in counting with acquisition score the covariate, and Table 21 gives the results for the acquisition and 6-week retention scores. The F's of 2.67 as shown in Table 20 and of 2.64 as shown in Table 21 are not significant at the .05 level, therefore, the hypothesis is ~~rejected.~~ accepted. Though not reported, analysis of covariance showed the same lack of significance of differenc between the acquisition and 18-week retention scores.

The adjusted means for retention in counting with acquisition scores the covariate are shown in Table 22. It is noted that the acquisition mean for

TABLE 20

ANALYSIS OF COVARIANCE FOR ACQUISITION AND FIVE-MINUTE RETENTION SCORES IN COUNTING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{yx}
Adjusted Means	8.92	2	4.46	2.67	
Within Groups	193.93	116	1.67		.768
Total	202.85	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 21

ANALYSIS OF COVARIANCE FOR ACQUISITION AND SIX-WEEK RETENTION SCORES IN COUNTING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{yx}
Adjusted Means	42.45	2	21.22	2.64	
Within Groups	933.73	116	8.05		.516
Total	976.18	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

the low IQ children was 7.55, the 5-minute retention mean was 7.35, and the adjusted retention mean, 8.40. The overall effect of the adjustment of the retention means was to raise that of the low IQ group which was originally low and to lower those of the average and high IQ groups which were originally high.

On the basis of the analysis of the acquisition-retention scores in counting, Hypothesis 2 is upheld---retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level. There is no difference in retention of counting among the three groups.

TABLE 22

ADJUSTED MEANS FOR RETENTION IN COUNTING WITH ACQUISITION SCORES THE COVARIATE

Scores	IQ Group	Adjusted Retention Means	Acquisition Means	Raw Score Retention Means
5-Minute Retention Counting	Low	8.40	7.55	7.35
	Average	9.03	9.52	9.50
	High	9.08	9.65	9.65
6-Week Retention Counting	Low	5.35	7.55	5.28
	Average	6.78	9.52	7.10
	High	7.60	9.65	7.98

Addition

Hypothesis 2 was also tested with a learning-retention task in addition. The main differences between the counting and the addition task were as follows. First, in counting all children used 19 minutes with unequal amounts of time for overlearning, whereas in addition there was no overlearning but time was permitted to vary from 4 to 17 minutes. Second, the scoring procedure in the counting task was to listen to the child to ascertain the number of correct responses in a series of ten; i.e. 3,6...33. In the addition task, the number of items correct was found by checking the child's written responses. Third, about fifty per cent of the correct responses were reinforced during acquisition of the counting task, whereas in acquisition of the addition task each item correctly worked was reinforced.

Table 23 gives the distribution of task levels in addition. It is seen that there was no overlapping between the low IQ children and the average and high IQ children. There was much overlapping between the average and the high IQ children, with most children in the latter two groups having as an appropriate acquisition task the adding of yards, feet, and inches with carrying and changing the units of measure. The range in task levels was quite wide for the low IQ

TABLE 23

DISTRIBUTION OF TASK LEVELS IN ADDITION

Description of Task*	Low IQ		Average IQ		High IQ	
	Boys	Girls	Boys	Girls	Boys	Girls
1. Sums to 6	4	10				
2. Sums to 10	3					
3. Sums to 15	5	3				
4. Sums to 19	3	1				
5. 2 addends, 2 digits each no carry	1	3				
6. 2 addends, 3 digits each no carry						
7. 2 addends, 2 digits each carry	4	3				
8. 2 addends, 3 digits each carry						
9. dollars and cents, 2 addends, 3 digits each, carry						
10. 3 addends, 3 digits each, carry				1		
11. Yards, feet, inches carry and change			19	19	16	17
12. Gallons, quarts, pints carry and change			1		2	2
18*. 2 Fractional addends simple and mixed numbers unlike denominators					2	1
Mean	3.50	2.95	11.05	10.95	11.80	11.45

*The task level indicates a new level of learning for the child which was next in order of difficulty above an addition task which the child could perform satisfactorily. Thus, the task level is one level above the child's addition skill at the time of testing. The table gives the number of children who were at each level. Levels 13 to 17 were omitted from the table because no subjects were found at those levels.

children with ten of the twenty girls and four of the twenty boys learning to add sums to six, and four low IQ boys and three low IQ girls learning to add items of two addends, two digits, with carrying. The mean task levels for the low, average, and high IQ boys were 3.50, 11.05, and 11.80, respectively. In all, the mean task levels of the boys was slightly higher than that of the girls.

TABLE 24

MEANS AND STANDARD DEVIATIONS FOR THE ACQUISITION AND RETENTION SCORES IN ADDITION

	Time to Learn in Seconds		Acquisition		5-Minute Retention		6-Week Retention	
	Mean	S.D.	Mean	S. D.	Mean	S. D.	Mean	S.D.
20 Low IQ Boys	584.00	202.70	5.90	3.14	5.95	2.91	4.90	3.03
20 Low IQ Girls	544.00	186.50	6.65	2.31	6.40	2.92	4.70	2.61
20 Av. IQ Boys	783.00	187.90	6.40	2.20	6.70	2.45	3.60	2.04
20 Av. IQ Girls	789.00	194.90	5.00	2.30	5.30	2.49	2.70	0.72
20 High IQ Boys	639.50	222.00	7.45	2.46	8.00	1.87	5.40	3.34
20 High IQ Girls	681.00	163.10	7.30	1.10	7.75	1.73	5.05	3.19
40 Low IQ	564.00	195.70	6.28	2.78	6.18	2.92	4.80	2.83
40 Av. IQ	786.00	191.30	5.70	2.36	6.00	2.57	3.15	1.59
40 High IQ	660.20	196.00	7.38	1.90	7.88	1.81	5.23	3.25
60 Boys	666.80	221.40	6.58	2.71	6.88	2.59	4.63	2.96
60 Girls	671.30	207.80	6.32	2.21	6.48	2.63	4.15	2.63
120 Subjects	670.10	214.90	6.45	2.48	6.68	2.62	4.39	2.80

Table 24 shows the means and standard deviations for the acquisition and retention scores in addition for the 20 children by sex and IQ groups and for the total 120 subjects. The mean number of the items acquired was 7.38 for the high IQ group, 6.28 for the low IQ group, and 5.70 for the average IQ group. Thus, the average IQ group had the lowest acquisition scores. This same pattern held for the 5-minute retention and 6-week retention measure. The 60 boys' mean scores were slightly higher than the 60 girls on the acquisition, 5-minute retention, and 6-week retention measures.

The correlations between acquisition and retention scores in addition are shown in Table 25. The range is from .87 to .89 for the three IQ groups between acquisition and 5-minute retention scores, and from .27 to .67 between acquisition and 6-week retention scores.

TABLE 25

CORRELATION BETWEEN ACQUISITION AND RETENTION SCORES IN ADDITION

IQ Level	r Acquisition and 5-Min. Retention	r Acquisition and 6-Week Retention
Low IQ	.89	.63
Average IQ	.87	.27
High IQ	.89	.67
All Subjects	.89	.56

The results of the analysis of variance for the acquisition scores in addition are shown in Table 26. The F of 5.15 is significant at or beyond the .01 level indicating a real difference in acquisition scores among the three IQ groups. The sex difference is not significant.

Table 27 gives the analysis of specific mean differences based upon the Tukey Tests for the acquisition scores in addition. A difference between means of 1.59 is required to be significant at the .01 level. The difference of .58 between the average and low IQ groups is not significant nor is that of 1.10 between the low and high IQ groups. However, the difference of 1.68 between the average and high IQ groups is statistically significant. The task was more difficult for the average IQ children than for the low or high IQ children, but was about equally difficult for the low and high IQ children.

TABLE 26

ANALYSIS OF VARIANCE FOR THE ACQUISITION SCORES IN ADDITION

Source of Variation	Sum of Squares	D.F.	Mean Square Deviation	F*
Sex	2.00	1	2.00	.35
IQ Level	59.00	2	29.50	5.15
Sex by IQ	22.00	2	11.00	1.92
Error	653.00	114	5.73	
Total	736.00			

*For significane at the .01 level, the F for sex must equal or exceed 6.87, for the .05 level, 3.93.
For significance at the .01 level, the Fs for IQ level and sex by IQ must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 27

ANALYSIS OF SPECIFIC MEAN DIFFERENCES FOR THE ACQUISITION SCORES IN ADDITION

IQ	$\bar{X}$	$\bar{X}$-5.70	$\bar{X}$-6.28
High	7.38	1.68	1.10
Low	6.28	.58	
Average	5.70		

*For significance at the .01 level, the difference must equal or exceed 1.59.

The results of the analyses of covariance for the acquisition and 5-minute retention scores and for the acquisition and 6-week retention scores are given in Tables 28 and 29. The F values of 3.24 and 3.60 are not sufficiently large to be significant at the .01 level. Therefore the hypothesis that retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level, is upheld. Though the conditions of acquisition were quite different in the addition task from the counting task, the results are essentially the same and the hypothesis is upheld for both areas of arithmetic learning.

TABLE 28

ANALYSIS OF COVARIANCE FOR ACQUISITION AND FIVE-MINUTE RETENTION SCORES IN ADDITION WITH ACQUISITION SCORE THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{yx}
Adjusted Mean	9.32	2	4.66	3.24	
Within Groups	167.41	116	1.44		.916
Total	176.73	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 29

ANALYSIS OF COVARIANCE FOR ACQUISITION AND SIX-WEEK RETENTION SCORES IN ADDITION WITH ACQUISITION SCORE THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{yx}
Adjusted Mean	37.54	2	18.77	3.60	
Within Groups	605.79	116	5.22		.598
Total	643.33	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

In Table 30 the adjusted means for retention in addition with acquisition scores the covariates are given. The effect of the adjustment is to reduce the difference among the retention means for the three IQ groups by raising that of the average IQ which was originally lowest and to reduce that of the high IQ which was originally highest.

TABLE 30

ADJUSTED MEANS FOR RETENTION IN ADDITION WITH ACQUISITION SCORES THE COVARIATE

Scores	IQ Group	Adjusted Retention Means	Acquisition Mean	Raw Score Retention Means
5-Minute Retention Addition	Low	6.34	6.28	6.18
	Average	6.69	5.70	6.00
	High	7.03	7.38	7.88
6-Week Retention Addition	Low	4.90	6.28	4.80
	Average	3.60	5.70	3.15
	High	4.67	7.38	5.23

Subtraction

The acquisition-retention measures in subtraction were secured in 1958-59 with essentially the same subjects as in 1957-58 and approximately twelve months later than the counting measures and approximately six months later than the addition measures. Two minor differences are noted between the addition and subtraction task. In subtraction no time limit was placed upon the child to complete the acquisition and retention measure, whereas in addition a 5-minute time limit was enforced. During the 5-minute rest interval for subtraction, a recorded story was used; during the 5-minute rest interval for addition the child read a book, looked at pictures, or was engaged by the examiner in conversation.

Table 31 gives the distribution of task levels in subtraction for the six groups by IQ level and sex. There is scarcely any overlap between the low IQ children and the average and high IQ children with only one average IQ child being at the same level as the highest low IQ child. There is considerable overlap between the average IQ group and the high IQ group with 33 of the 40

TABLE 31

DISTRIBUTION OF TASK LEVELS IN SUBTRACTION

Description of Task	Low IQ		Average IQ		High IQ	
	Boys	Girls	Boys	Girls	Boys	Girls
1. Minuends to 6	3	7				
2. Minuends to 10	10	3				
3. Minuends to 15	5	4				
4. Minuends to 19, 1 digit subtrahend	1	3				
5. 2-digit minuend, 2-digit subtrahend, no borrow	1	1				
6. 3-digit minuend and subtrahend, no borrow						
7. 2-digit minuend and subtrahend, borrow		2	1			
8. 3-digit minuend and subtrahend, 1 borrow						
9. 3-digit minuend and subtrahend, 2 borrow						
10. 3-digit minuend and subtrahend with money, borrow						
11. Yards, feet, inches, no change						
12. Days, hours, minutes, no change						
13. Feet, inches borrow and change			15	18	6	4
14. Hours, minutes borrow and change						2
18. Mixed numbers, borrow and change			4	2	13	13
19. Fractions-unlike denominators, no borrow					1	1
Mean	2.35	2.80	13.70	13.50	16.55	16.65

average IQ children and 10 of the 40 high IQ children having as an appropriate task the subtraction of feet and inches with borrowing and changing feet to inches. Twenty-six high IQ children could subtract common fractions with borrowing, and thus had as an appropriate task subtracting mixed numbers involving borrowing and changing whole numbers to fractions. Six average IQ children were also at this level. The mean task level, 2.80, for the low IQ girls was somewhat higher than that for the low IQ boys, 2.35. There was little difference between the boys, 13.70, and the girls, 13.50, of average and high intelligence. There was a definite progression of higher task levels according to IQ group as shown by the means of 2.35, 13.70, and 16.55 for low, average, and high IQ boys, respectively.

The means and standard deviations for the acquisition and retention scores in subtraction are given in Table 32. Though the task levels for the IQ groups were quite different as previously noted, the mean acquisition scores were very much alike with the high IQ children showing a slightly higher mean, 8.95, than the low IQ, 7.97, and the average IQ, 7.85. For the total 120 subjects there was a slight increase in mean, 5-minute retention, 8.33, over acquisition, 8.25, a decrease for 7-week retention, 7.51, and a small increase again for the 14-week retention measure, 7.97. The differences among mean scores between boys and girls was quite small throughout the acquisition-retention sequence of measures.

The correlations between acquisition and retention scores in subtraction are given in Table 33. For the three IQ groups the correlations between acquisition and 5-minute retention ranged from about .60 to .87. For the total group the correlation was .74. The correlations between acquisition and 7-week retention scores ranged from .30 to .53 for the three IQ groups and was .43 for the total group.

The results of the analysis of variance for the acquisition scores in subtraction are shown in Table 34. The largest F, 3.08, for difference among the three IQ groups, is not significant at the .01 level. Thus, while the difference among IQ groups was significant on the addition task as previously noted it was not significant at the .01 level on the subtraction task. However, in subtraction as addition the largest difference among mean scores was between the average and high IQ groups with the average IQ group having the lower score.

TABLE 32

MEANS AND STANDARD DEVIATIONS FOR THE ACQUISITION AND RETENTION SCORES IN SUBTRACTION

	Time to Learn Secs.		Acquisition		5-Minute Ret.		7-Week Ret.		14-Week Ret.	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
20 Low IQ Boys	633.2	121.58	7.95	2.08	7.60	2.31	7.80	2.03	7.75	2.42
20 Low IQ Girls	687.6	95.53	8.00	2.40	8.00	3.06	6.85	3.08	6.55	3.35
20 Av. IQ Boys	719.9	142.40	7.60	2.83	8.25	2.62	6.90	3.57	8.60	2.05
20 Av. IQ Girls	763.85	194.49	8.10	1.26	7.95	1.93	7.50	2.57	7.70	2.98
20 Hi. IQ Boys	649.70	102.45	9.10	1.37	9.65	.72	8.50	2.95	8.85	2.96
20 Hi. IQ Girls	766.85	130.40	8.80	2.31	8.55	2.65	7.55	3.70	8.40	3.20
40 Low IQ	660.40	109.32	7.97	2.23	7.80	2.71	7.32	2.60	7.15	2.92
40 Av. IQ	741.87	171.87	7.85	2.19	8.10	2.30	7.20	3.11	8.15	2.55
40 Hi. IQ	708.27	117.26	8.95	1.89	9.10	1.94	8.02	3.34	8.62	3.08
60 Boys	667.60	123.22	8.21	2.17	8.50	2.05	7.73	2.91	8.40	2.54
60 Girls	739.43	146.00	8.30	2.05	8.16	2.58	7.30	3.15	7.55	3.18
120 Subjects	703.51	135.09	8.25	2.11	8.33	2.33	7.51	3.03	7.97	2.87

TABLE 33

CORRELATIONS BETWEEN ACQUISITION AND RETENTION SCORES IN SUBTRACTION

IQ Level	r Acquisition 5-Min. Ret.	r Acquisition 7-Week Ret.
Low IQ	.69	.45
Average IQ	.87	.30
High IQ	.60	.53
All Subjects	.74	.43

TABLE 34

ANALYSES OF VARIANCE FOR THE ACQUISITION SCORES IN SUBTRACTION

Source of Variation	Sum of Squares	DF	Mean Square Deviation	F*
Sex	.2	1	.2	.02
IQ Level	29.0	2	14.5	3.08
Sex by IQ	3.2	2	1.6	.34
Error	536.6	114	4.7	
Total	569.0			

*For significance at the .01 level, the F for sex must equal or exceed 6.87, for the .05 level, 3.93.
For significance at the .01 level, the Fs for IQ level and sex by IQ must equal or exceed 4.80, for the .05 level, 3.08.

The results of the Tukey Tests shown in Table 35, which presents the analysi of specific mean differences for the acquisition scores in subtraction, reveal no difference among the three IQ groups significant at the .01 level. The difference of 1.10 between the average and high IQ groups does not reach 1.44, the level needed for significance at the .01 level.

TABLE 35

ANALYSIS OF SPECIFIC MEAN DIFFERENCES FOR THE ACQUISITION SCORES IN SUBTRACTION

IQ	$\bar{X}$	$\bar{X} - 7.85$	$\bar{X} - 7.97$
High	8.95	1.10	.98
Low	7.97	.12	
Average	7.85		

*The difference must equal or exceed 1.44 for significance at the .01 level.

The results of the analyses of covariance for acquisition and 5-minute retention and for acquisition and 7-week retention in subtraction are shown in Tables 36 and 37. The F values of 1.26 and .03 are not significant at the .01 level. Therefore, the hypothesis is accepted---retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level.

TABLE 36

ANALYSES OF COVARIANCE FOR ACQUISITION AND FIVE-MINUTE RETENTION SCORES IN SUBTRACTION WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{YX}
Adjusted Mean	6.2	2	3.10	1.26	.77
Within Groups	284.7	116	2.45		
Total	290.9	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

TABLE 37

ANALYSIS OF COVARIANCE FOR ACQUISITION AND SEVEN-WEEK RETENTION SCORES IN SUBTRACTION WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	DF	Mean Square	F*	b_{yx}
Adjusted Mean	.6	2	.3	.03	.60
Within Groups	936.6	116	8.07		
Total	937.2	118			

*For significance at the .01 level, F must equal or exceed 4.80, for the .05 level, 3.08.

The adjusted mean scores for retention in subtraction with acquisition scores the covariate are shown in Table 38. The adjustment reduced differences among retention means very little. With no significant difference having been found among the three IQ groups in acquisition, it was not essential to use analysis of covariance with acquisition scores the covariate. However, since covariance was used with counting and addition, it was continued with subtraction and differentiated problem-solving.

TABLE 38

ADJUSTED MEANS FOR RETENTION IN SUBTRACTION WITH ACQUISITION SCORES THE COVARIATE

Scores	IQ Group	Adjusted Retention Means	Acquisition Means	Raw Retention Means
5-Minute Retention Subtraction	Low	8.01	7.97	7.80
	Average	8.40	7.85	8.10
	High	8.57	8.95	9.10
7-Week Retention Subtraction	Low	7.48	7.97	7.32
	Average	7.44	7.85	7.20
	High	8.68	8.95	8.02

In summary, the same results regarding retention were found in subtraction as in addition and counting. When the original learning is graded to each chil achievement level, retention of subtraction learning is the same among children of low, average, and high intelligence.

Differentiated Problem-Solving

The last test of Hypothesis 2 was made with the differentiated problem-solving task in the second semester of 1958-59. Different from the common problem-solving task, reported upon previously, the differentiated problem-solving task was set up with three main levels of difficulty. The three levels, A, B, and C, are reported in Table 39. Series A problems were in a moderately graduated sequence from easy to more difficult with problems 1a-c being easiest and used with the least proficient low IQ children who could not identify the proper denominations and total numbers of coins to make 7, 8, and 9 cents, respectively. Problems 3a-c required the child to identify the proper denominations and total number of coins to make amounts of 46, 47, and 48 cents, respectively. The four problems in Level B were equally difficult as were the first four in Level C. Problems 9a-d, and 10a-d in Level R were held in reserve for any child who might go above Level C. Based upon tests with other children not in the study, the levels of difficulty were determined as above and a tentative assignment of a problem was made for each child in the study prior to presenting the differentiated problem-solving task to any child. If the child solved the assigned problem in less than three minutes, he was given a more difficult problem. Table 39 shows that all low IQ children worked within Level A, 37 of the 40 average IQ children worked within Level B, and all 40 of the high IQ children worked within Level C. No Reserve problem was needed. (See Appendix H for further description of the tasks.)

No overlearning was permitted in the differentiated problem-solving task and the score used was the number of seconds to learn or relearn. In order

TABLE 39

DISTRIBUTION OF TASK LEVELS IN DIFFERENTIATED PROBLEM-SOLVING

Task Level*	Low IQ Boys	Low IQ Girls	Average IQ Boys	Average IQ Girls	High IQ Boys	High IQ Girls
A 1 a-c	11	13				
A 2 a-c	2	5				
A 3 a-c	7	2				
A 4 a-c						
A 5 a-c						
A 6 a-c						
B 7 a-d			18	19		
C 8 a-d			2	1	19	19
C 9 a-d					1	1
R 10 a-d						

*No subject worked at Level 4, 5, 6, and 10. This was due to the design of the problem-solving task levels. Levels 1-6 were appropriate for the low subjects. Levels 7 and 8 were most suitable to the average subjects and Levels 8 and 9 for the high IQ children. Levels 4, 5, and 6 were included in the event some one of the low subjects would find the first three levels not adequate. Likewise, Level 10 was included for the high subjects.

that each child reached a correct solution cues or helps were given at definite time intervals. Further, the 120 children were randomly divided into two groups with an equal number of boys and girls from each IQ level to form one group of 60 hereafter called the retention group, and one group of 60 hereafter galled the transfer group. Children in the transfer group were given a new problem for each of the relearning measures whereas the children in the retention group were given the same problem as had been assigned to them for acquisition.

In Table 40 are given the means and ranges for levels of help in differentiated problem-solving for the retention group. The levels of help provided the six groups by IQ and sex were much the same with the high IQ group requiring slightly less help than the other two groups in learning to solve the assigned problems. A similar pattern is revealed for the 5-minute relearning measure and the 7-week relearning measure. Thus, the difficulty of problems was approximately equal for the three IQ groups insofar as help needed to reach a solution was concerned.

Table 41 shows the means and standard deviations for the acquisition and retention scores in seconds in differentiated problem-solving according to seven major categories. The first category, method, shows the mean scores for the 60 subjects in the retention group, and for the 60 subjects in the transfer group. Though the two groups were drawn using a table of random numbers, it is seen that the retention boys and girls used slightly less time, 567.06 seconds, than did the transfer boys and girls, 653.13 seconds, in achieving a first solution to the problem. Noticeable differences among means are shown between the retention group, 112.69 seconds, and the transfer group, 484.71 seconds, for the 5-minute retention measure. At the end of the seven weeks the difference was decreasing with the retention group requiring 261.83 seconds and the transfe group requiring 420.55 seconds. Thus, between the 5-minute and 7-week measures, performance improved for the transfer group, but deteriorated for the retention group. While administering the 5-minute retention measure, the researchers observed that many boys and girls in the retention group remembered the correct solution to the problem and thus achieved the solution very quickly. However, when the researchers came back seven weeks later the retention boys and girls had forgotten the solution and therefore required considerably more time to relearn than they had at the end of the 5-minute rest interval. The transfer group, on the other hand, showed progressive improvement in the acquisition, 5-minute and 7-week measures. It is hypothesized that had a fourth problem

TABLE 40

MEANS AND RANGES FOR LEVELS OF HELP IN DIFFERENTIATED PROBLEM-SOLVING FOR THE RETENTION GROUP

	Learning		5-Min. Relearning		7-Week Relearning	
	Mean	Range	Mean	Range	Mean	Range
Low IQ Boys	1.70	0-3	0	0	0	0
Low IQ Girls	1.60	0-3	.5	0-2	.8	0-3
Av. IQ Boys	1.70	0-3	0	0	1.0	0-3
Av. IQ Girls	1.50	0-3	.3	0-3	.5	0-3
High IQ Boys	1.30	0-3	0	0	.6	0-3
High IQ Girls	1.00	0-3	.3	0-3	0	0

TABLE 41

MEANS AND STANDARD DEVIATIONS FOR ACQUISITION AND RETENTION SCORES IN DIFFERENTIATED PROBLEM-SOLVING

		N	Time to Learn in Seconds		5-Min. Retention Time in Seconds		7-Week Retention Time in Seconds	
			Mean	S.D.	Mean	S.D.	Mean	S.D.
Method								
Retention		60	567.06	249.29	112.69	214.32	261.83	254.98
Transfer		60	653.13	220.70	484.71	301.95	420.55	285.64
IQ								
Low		40	624.17	209.11	304.40	262.36	302.45	268.00
Average		40	627.65	252.34	271.32	243.89	415.05	295.72
High		40	578.47	242.66	320.40	278.13	306.07	246.24
Sex								
Boys		60	615.02	242.28	235.75	244.49	322.82	280.81
Girls		60	605.18	228.37	361.66	378.09	359.56	260.29
Method by IQ								
Retention	Low	20	569.20	256.77	107.55	214.14	189.00	246.71
	Average	20	590.30	252.31	84.70	183.16	362.75	298.42
	High	20	541.70	238.44	145.85	241.67	233.75	212.47
Transfer	Low	20	679.15	146.73	501.25	303.01	415.90	287.72
	Average	20	665.00	252.35	457.95	292.26	467.35	293.00
	High	20	615.25	246.83	494.95	310.34	378.40	275.92

Continued on next page.

TABLE 41, Continued

MEANS AND STANDARD DEVIATIONS FOR ACQUISITION AND RETENTION SCORES IN DIFFERENTIATED PROBLEM-SOLVING

	N	Time to Learn in Seconds		5-Min. Retention Time in Seconds		7-Week Retention Time in Seconds	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Method by Sex							
Retention Boys	30	567.13	260.73	71.63	155.33	255.13	272.55
Girls	30	567.00	237.30	153.76	260.28	268.53	236.12
Transfer Boys	30	662.90	222.32	399.86	308.92	390.50	288.84
Girls	30	643.36	219.08	569.56	294.83	450.60	282.41
IQ by Sex							
Low Boys	20	612.75	227.11	202.60	236.95	216.95	233.30
Girls	20	635.60	189.17	406.15	285.53	388.00	298.71
Average Boys	20	662.55	240.16	199.25	217.45	452.75	336.69
Girls	20	592.75	263.94	343.45	267.73	377.40	250.76
High Boys	20	569.75	258.36	305.40	275.52	298.80	262.25
Girls	20	587.20	225.90	335.65	280.72	313.35	229.13
Method by IQ by Sex							
Retention Low Boys	10	568.10	270.58	49.30	67.89	98.10	114.10
Girls	10	570.30	242.19	165.80	295.14	279.90	329.73
Av. Boys	10	572.60	260.32	32.80	26.38	381.10	357.19
Girls	10	608.00	244.04	136.60	257.69	344.40	224.73
High Boys	10	560.70	250.92	132.80	259.01	286.20	286.79
Girls	10	522.70	225.30	158.90	223.00	181.30	89.68
Transfer Low Boys	10	657.40	173.63	356.00	328.15	335.70	309.58
Girls	10	700.90	113.64	646.50	275.59	496.10	264.08
Av. Boys	10	752.50	218.15	365.70	306.40	524.30	314.86
Girls	10	577.50	282.45	550.20	277.41	410.40	269.39
High Boys	10	578.80	265.61	477.90	291.10	311.50	235.18
Girls	10	651.70	226.51	512.20	328.46	445.30	311.39

been given to the transfer group at the end of 14 weeks the transfer group then would probably have achieved a solution about as quickly as would the retention group have achieved a solution of the identical problem. The rest of the descriptive data presented in Table 41 is subsequently treated by analysis of variance in Table 43 and covariance in Table 44.

In Table 42 are presented the correlations between acquisition and retention scores for the retention and transfer subjects in differentiated problem-solving. The correlations between acquisition and 5-minute relearning times range from .33 to .64 for the retention subjects according to IQ level, and for the 60 retention subjects the correlation is .43. The comparable correlations for the transfer subjects range from .03 to .40, and for the 60 transfer subjects the correlation is .15. Similar differences are noted between the retention and transfer subjects in the correlations between acquisition and 7-week relearning scores. For the 60 transfer subjects the correlation is .05 and for the 60 retention subjects it is .31. As might be expected, the correlation: between acquisition and subsequent relearning are lower for the transfer than fo: the retention subjects.

TABLE 42

CORRELATIONS BETWEEN ACQUISITION AND RETENTION SCORES FOR THE RETENTION AND TRANSFER SUBJECTS IN DIFFERENTIATED PROBLEM-SOLVING

	RETENTION SUBJECTS		TRANSFER SUBJECTS	
IQ Level	Acquisition & 5-Min. Ret.	Acquisition & 7-Week Ret.	Acquisition & 5-Min. Ret.	Acquisition 7-Week Ret
Low IQ	.34	.42	.40	.45
Average IQ	.33	.23	.03	-.16
High IQ	.64	.55	.13	-.03
60 Subjects	.43	.31	.15	.05

The results of the analysis of variance for the detailed information presented in Table 41 on the acquisition time for problem-solving are now given in Table 43. It is seen that no F is sufficiently large to be significantly different from 0 at the .05 level. The F of 3.61 is somewhat larger than

TABLE 43

ANALYSIS OF VARIANCE FOR ACQUISITION SCORES IN DIFFERENTIATED PROBLEM-SOLVING

Source of Variation	Sum of Squares	DF	Mean Square Deviation	F*
Method	222224.1	1	222224.1	3.61
IQ Level	60249.9	2	30124.9	.49
Sex	2900.8	1	2900.8	.04
Method by IQ	8562.9	2	4281.4	.06
Method by Sex	2822.7	1	2822.7	.04
IQ by Sex	54085.9	2	27042.9	.44
Method by IQ by Sex	142858.9	2	71429.4	1.16
Error	6636640.0	108	61450.3	

* For significance at the .01 level, the F's for Method, Sex, and Method by Sex must equal or exceed 6.88, for the .05 level, 3.93.
For significance at the .01 level, the F's for IQ level, Method by IQ, IQ by sex, and Method by IQ by Sex must equal or exceed 4.81, for the .05 level, 3.08.

anticipated inasmuch as the group of 120 subjects were divided randomly into the transfer and retention groups. However, since the difference between the groups is not significant at the .05 level, the researchers concluded that the problems assigned to the transfer and retention groups were of equal difficulty. Further a very small and nonsignificant F,1.49, was obtained according to IQ groups. The problem-solving tasks were of the same difficulty for the children in the three IQ groups.

The results of the analysis of covariance for acquisition and 5-minute retention scores and for acquisition and 7-week retention scores in differentiated problem-solving are shown in Tables 44 and 45, as applied to the retention group. The F's of .67 and 2.13 are not significantly different from 0 at the .05 level. Thus, this portion of the test supports Hypothesis 2, that retention in differentiated problem-solving is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level.

TABLE 44

ANALYSIS OF COVARIANCE FOR ACQUISITION AND FIVE-MINUTE RETENTION SCORES IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	D.F.	Mean Square	F*	b_{yx}
Adjusted Mean	59826.3	2	29913.1	.67	.32
Within Groups	2486921.3	56	44409.3		
Total	2546747.6	58			

*For significance at the .01 level, F must equal or exceed 5.01, for the .05 level, 3.17.

TABLE 45

ANALYSIS OF COVARIANCE FOR ACQUISITION AND SEVEN-WEEK RETENTION SCORES IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	D.F.	Mean Squares	F*	b_{yx}
Adjusted Mean	286115.8	2	143057.9	2.13	.32
Withing Groups	3747802.6	56	66925.0		
Total	4033918.4	58			

*For significance at the .01 level, F must equal or exceed 5.01, for the .05 level, 3.17.

In Tables 46 and 47 are presented the results of the analysis of covariance for the acquisition and 5-minute transfer scores and for acquisition and 7-week transfer scores in differentiated problem-solving. The F's of .12 and .42 are not significant at the .05 level. Thus, when the applied measure of retention, transfer, is used in testing the hypothesis, the results are the same. There is no difference among the three IQ groups in retention.

TABLE 46

ANALYSIS OF COVARIANCE FOR ACQUISITION AND FIVE-MINUTE TRANSFER SCORES IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	D.F.	Mean Square	F*	b_{yx}
Adjusted Mean	26032.1	2	13016.0	.12	.20
Within Groups	5936295.8	56	106005.2		
Total	5962327.9	58			

*For significance at the .01 level, F must equal or exceed 5.01, for the .05 level, 3.17.

TABLE 47

ANALYSIS OF COVARIANCE FOR ACQUISITION AND SEVEN-WEEK TRANSFER SCORES IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Source of Variation	Sum of Squares of Errors of Estimate	D.F.	Mean Square	F*	b_{yx}
Adjusted Mean	78070.0	2	39035.0	.42	.04
Within Groups	5173764.0	56	92388.6		
Total	5251834.0	58			

* For significance at the .01 level, F must equal or exceed 5.01, for the .05 level, 3.17.

As is shown in Table 48 and in Table 49, the time-to-learn mean scores were much alike for the three IQ groups, therefore, the adjusted retention mean scores are not greatly dissimilar to the original raw score retention means

In summary of the four tests of Hypothesis 2 in which counting, addition, subtraction, and differentiated problem-solving were used, the unqualified conclusion is that retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level. With purposefully designed variations in the

TABLE 48

ADJUSTED MEANS FOR RETENTION SCORES OF THE RETENTION GROUP IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Scores	IQ Group	Adjusted Retention Means	Time to Learn Means	Raw Retention Means
5-Minute Retention Problem-Solving	Low	106.8	569.2	107.5
	Average	77.3	590.3	84.7
	High	161.3	541.7	145.8
7-Week Retention Problem-Solving	Low	188.3	569.2	189.0
	Average	405.2	590.3	412.7
	High	241.7	541.7	233.7

TABLE 49

ADJUSTED MEANS FOR TRANSFER SCORES OF THE TRANSFER GROUP IN DIFFERENTIATED PROBLEM-SOLVING WITH ACQUISITION SCORES THE COVARIATE

Scores	IQ Group	Adjusted Transfer Means	Time to Learn Means	Raw Transfer Means
5-Minute Transfer Problem-Solving	Low	496.0	679.1	501.2
	Average	455.6	665.0	457.9
	High	502.4	615.2	494.9
7-Week Transfer Problem-Solving	Low	414.9	679.1	415.9
	Average	466.8	665.0	467.3
	High	379.9	615.2	378.4

teaching-learning procedures, with the subjects at four different mean ages, and with applied and direct measures of retention at 5-minute, 6-week, and 12 week intervals the same results were obtained.

HYPOTHESIS 3: UNEVEN PHYSICAL DEVELOPMENT

Hypothesis 3 states that uneven physical development within the child accompanies low efficiency in arithmetic achievement and in reaching achievement. This hypothesis deals with the phenomenon of split-growth and implies that the more unevenness in physical development, the lower the achievement. As discussed previously in the design section, 40 boys and 40 girls were drawn randomly from a larger child population but included some of the 120 children used in testing the two hypotheses discussed previously. The method for computing the score of uneven physical development as shown in height, weight, strength of grip, and carpal age was also presented previously in the design section.

The means, standard deviations, and ranges for 10 measures of the 40 boys and 40 girls in 1956-57 at 101 months of age, in 1957-58 at 113 months of age, and in 1958-59 at 125 months of age are given in Tables 50, 51, and 52.

At 113 months of age the boys were taller than the girls, however, at 125 months the girls were slightly taller than the boys. At both ages the boys weig more and were stronger than the girls. At both ages the girls had more permanent teeth than the boys and also were slightly advanced in carpal age. By the method of drawing the sample the WISC IQ's were nearly the same for both boys and girls for both years. At both 113 and 125 months of age, the girls scored higher in reading, arithmetic, and language, with the girls' superiority in language quite marked. By the selection method the chronological age of the boys and girls was much the same at 113 months and also at 125 months. At 113 months of age the girls' achievement in reading and language was considerably higher than their mean chronological age; but all the achievement scores for the boys, and the girls' achievement scores in arithmetic were close to chronological age. The same pattern held for the children at 125 months of age.

TABLE 50

MEAN RAW SCORES, STANDARD DEVIATIONS, AND RANGE OF TEN MEASURES FOR FORTY BOYS AND FORTY GIRLS DISTRIBUTED NORMALLY ACCORDING TO IQ AT 101 MONTHS OF AGE

Measure	BOYS Mean Raw Score	Standard Deviation	Range	GIRLS Mean Raw Score	Standard Deviation	Range
Chronological age	101.20	4.18	95-110	101.73	3.84	94-110
Height in inches	52.11	2.52	47- 58	51.59	1.97	47- 56
Weight in pounds	65.97	11.48	49- 94	64.74	11.05	45- 94
Grip in kilograms	17.55	3.20	11- 23	14.92	2.92	10- 22
Number of Permanent teeth	10.40	2.68	2- 18	12.15	1.66	10- 18
Carpal age in months	97.98	11.42	69-120	101.28	8.09	83-119
WISC IQ	102.88	16.05	58-136	101.43	14.89	67-126
Cal.reading	54.03	19.86	6- 83	64.98	13.65	23- 82
Cal.arithmetic	30.13	14.47	3- 67	35.03	10.78	4- 53
Cal.language	12.40	7.08	0- 33	16.30	5.99	0- 26

TABLE 51

MEANS, STANDARD DEVIATIONS, AND RANGES FOR TEN MEASURES OF FORTY BOYS AND FORTY GIRLS, NORMALLY DISTRIBUTED ACCORDING TO WISC IQ AT 113 MONTHS OF AGE

Measure	BOYS Mean Raw Score	Standard Deviation	Range	GIRLS Mean Raw Score	Standard Deviation	Range
Height in inches	53.38	2.36	48.6- 57.7	52.89	2.21	49.0- 57.5
Weight in pounds	70.89	13.12	48.0-108.4	67.72	11.86	46.0- 94.0
Grip in kilograms	18.96	3.12	13.0- 26.2	16.08	2.26	9.7- 20.6
Permanent teeth	12.83	3.20	7.0- 26.0	14.48	3.40	10.0- 24.0
Carpal Age in months	109.80	12.37	80.0-137.0	112.00	11.96	86.0-131.0
WISC IQ	100.68	14.86	62.0-136.0	100.33	15.27	63.0-135.0
Cal.reading (mo.)	113.08	17.49	76.0-155.0	124.20	16.92	85.0-160.0
Cal.arithmetic (mo.)	110.73	11.79	88.0-133.0	112.95	8.67	87.0-129.0
Cal.language (mo.)	115.08	16.18	72.0-142.0	126.53	13.49	84.0-149.0
Chronological Age (Mo.)	112.70	3.57	107.0-119.0	113.00	3.84	106.0-119.0

The correlations between uneven physical development, or split-growth, and achievement in reading and arithmetic for children at 101, 113, and 125 months of age are given in Table [illegible]. The correlations for the measures of the children at 101 months of age are based upon the pilot study previously outlined in Part I. Table 53 shows that none of the correlations were significant at

TABLE 52

MEANS, STANDARD DEVIATIONS, AND RANGES FOR TEN MEASURES OF 40 BOYS AND 40 GIRLS, NORMALLY DISTRIBUTED ACCORDING TO WISC IQ, AT 125 MONTHS OF AGE

Measure	BOYS Mean	S.D.	Range	GIRLS Mean	S.D.	Range
Height in inches	55.10	2.80	47.9- 60.8	55.24	2.41	50.8- 60.0
Weight in Pounds	77.22	16.23	49.3-113.3	75.36	13.78	55.0-111.5
Grip in kilograms	20.90	3.47	13.0- 28.5	17.70	3.28	9.4- 23.7
Permanent teeth	15.05	4.37	11.0- 28.0	16.45	4.53	11.0- 27.0
Carpal age in months	120.65	13.77	89.0-153.0	124.80	9.52	101.0-156.0
WISC IQ	100.60	15.62	62.0-136.0	100.83	15.22	63.0-135.0
Cal. reading (mo.)	125.90	21.87	81.0-166.0	135.80	21.74	82.0-166.0
Cal.arithmetic (mo.)	122.20	15.17	86.0-149.0	124.63	12.88	92.0-139.0
Cal.language (mo.)	122.53	19.00	72.0-149.0	132.58	18.35	82.0-157.0
Chronological age (mo.)	124.60	3.46	119.0-131.0	125.60	3.78	118.0-132.0

the .01 level. However, with the children at a mean age of 113 and 125 months, al the correlations were negative, the hypothesized direction. In 1958-59 two of the correlations, both for girls, were significantly different from 0 at .05 level The consistent pattern of negative correlations tends to support the hypothesis. that the more uneven the child's physical growth within himself the greater the likelihood of lower achievement in reading and in arithmetic. In computing the score for uneven physical development each measure was given equal weight. It is possible that differences within the child in the observable measures such as height and weight, or differences within the child in the two not readily observed measures, strength of grip and carpal age, might be contributing to this persisten negative correlation.

In summary, the hypothesis that uneven physical development within the child accompanies low efficiency in arithmetic achievement and in reading achievement is not supported. However, the persistent trend of negative correlations suggest that this hypothesis is worth further investigation.

TABLE 53

CORRELATIONS BETWEEN UNEVEN PHYSICAL DEVELOPMENT (SPLIT-GROWTH) AND ACHIEVEMENT IN ARITHMETIC AND READING WITH SUBJECTS AT MEAN AGES OF 101, 113, AND 125 MONTHS

Variability in Physical Development As Measured At One Year Intervals	ARITHMETIC		READING	
	Boys	Girls	Boys	Girls
Variability Measured in 1956	-.03	-.07	.05	.01
Variability Measured in 1957	-.26	-.19	-.26	-.18
Variability Measured in 1958	-.09	-.38*	-.09	-.32*

*For significance at the .05 level, r must equal or exceed .304 and for significa at the .01 level, .393.

HYPOTHESIS 4: LEVEL OF PHYSICAL DEVELOPMENT

As discussed in the design section in Chapter 1, a level of physical development score was computed for each child and these scores for boys and girls were subsequently correlated with standardized achievement test scores in reading and in arithmetic.

The correlations between level of physical development and achievement in arithmetic and in reading with subjects at mean ages of 101, 113, and 125 months are shown in Table 54. The correlations between level of physical development and reading and arithmetic are higher for boys than for girls, although only at 101 months of age were the correlations, for boys, .51 and .44, significant at the .01 level. The other correlations are small and positive but not significant different from 0 at the .05 level. Subsequently in Table 57 it will be shown that the correlations between grip and achievement in reading and arithmetic for both sexes are significantly different from 0 at the .01 level for children at a mean age of 113 months and 125 months. Thus, strength of grip correlates higher with achievement in reading and arithmetic than does the combined measure of level of physical development used in testing this hypothesis.

In summary, the hypothesis is rejected that a low level of physical development within the child accompanies low achievement in arithmetic and reading.

Further, on the basis of the high correlations subsequently reported between strength of grip and reading and arithmetic achievement, the researchers believe there is little to be gained from further study of level of physical development with children in the age range of 94 to 132 months.

TABLE 54

CORRELATIONS BETWEEN LEVEL OF PHYSICAL DEVELOPMENT AND ACHIEVEMENT IN ARITHMETIC AND READING WITH THE SUBJECTS AT MEAN AGES OF 101, 113, AND 125 MONTHS

Level of Physical Development As Measured at One Year Intervals	ARITHMETIC Boys	ARITHMETIC Girls	READING Boys	READING Girls
Level of Physical Development in 1956	.51*	.07	.44*	.05
Level of Physical Development in 1957	.22	.16	.19	.20
Level of Physical Development in 1958	.20	.08	.25	.11

*For significance at the .05 level, r must equal or exceed .304, and for significance at the .01 level, .393.

HYPOTHESIS 5: WITHIN-CHILD VARIABILITY

Hypothesis 5 states that the within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithmetic achievement is the same among children of low, average and high intelligence. A truncate hypothesis is that the within-child variability in reading, language, and arithmetic achievement is the same among children of low, average, and high intelligence. The procedures for computing the within-child variability scores were presented in the design section of Part I. The hypothesis was tested by analysis of variance with the .01 level of significance used as a basis for acceptance or rejection.

Table 55 presents a summary of the results of the analyses of variance for the main and the truncated hypotheses with children at mean ages of 101, 113, and 125 months of age. (Space does not permit the inclusion of all the separate tables of which Table 55 is a summary.) At all three ages the differences between boys and girls in within-child variability were not significant; that is, within-child variability in the five measures was the same for boys and girls. In 1956 with children at a mean age of 101 months there was a significant difference between boys and girls in within-child variability in the three achievement measures---arithmetic, reading, and language achievement with the girls showing higher within-child variability than the boys. The difference between sexes was not significant at 113 and 125 months of age.

TABLE 55

RESULTS OF ANALYSES OF VARIANCE SHOWING SIGNIFICANCE OF DIFFERENCES AMONG MEANS OF WITHIN-CHILD VARIABILITY IN FIVE AND THREE MEASURES WITH SUBJECTS AT MEAN AGES OF 101, 113, and 125 MONTHS

GROUPS	1956 -101 Mos.		1957-113 Mos.		1958 - 125 Mos.	
	5 Meas.	3 Meas.	5 Meas.	3 Meas.	5 Meas.	3 Meas.
SEX - 60 Boys, 60 Girls	NS*	.01	NS	NS	NS	NS
IQ - 40 Low, 40 Average 40 High	.05	NS	.01	NS	.01	NS
Sex x IQ Interaction	.01	NS	NS	.05	NS	NS

*NS means no significant difference among or between means, .05 means the difference is significant at or beyond the .05 level, and .01 means it is significant at or beyond the .01 level.

The difference among the three IQ groups in within-child variability in grip, IQ, reading, arithmetic, and language acheivement was significant at the .05 level in 1956, at the .01 level in 1957, and at the .01 level in 1958. A significant interaction effect was found at the .01 level in 1956. Thus, the significant difference at the .05 level between boys and girls in 1956 must be interpreted in terms of the significant interaction. Comparison of means, reported subsequently in Table 56, shows that the average IQ children were least variable in the five measures.

The differences among the three IQ groups in within-child variability in reading, arithmetic, and language achievement was found not statistically significant in 1956, 1957, and 1958. Children in the three IQ groups are equally variable within themselves in their levels of achievement.

Table 56 shows the means for the within-child variability in the five and three measures with the subjects at mean ages of 101, 113, and 125 months. It is noted that the within-child variability scores in the five measures for each year for the 60 boys and 60 girls are very much alike. In addition, the within-child variability scores in reading, arithmetic, and language are much alike except for 1956 where girls showed the higher degree of within-child variability as reported previously.

TABLE 56

MEANS FOR WITHIN-CHILD VARIABILITY IN FIVE AND THREE MEASURES WITH SUBJECTS AT MEANS AGES OF 101, 113, and 125 MONTHS

GROUP	Means for Five Measures (Strength, IQ, Reading, Arithmetic, Language)			Means for Three Measures (Reading, Arithmetic, Language)		
	1956	1957	1958	1956	1957	1958
120 Children	.590	.589	.591	.290	.280	.232
60 Boys	.537	.603	.586	.231	.256	.232
60 Girls	.642	.576	.579	.349	.304	.231
40 Low IQ	.679	.638	.640	.288	.287	.220
40 Average IQ	.483	.429	.416	.299	.250	.207
40 High IQ	.607	.702	.692	.284	.303	.268

The mean within-child variability scores according to IQ groups also reveal much similarity among the three IQ groups in reading, arithmetic, and language, but in the five measures the average IQ children are much less variable than are the low or high IQ children. The low and high IQ children show about the sam amount of variability.

In summary of these tests of the main hypothesis and the truncated hypothesis, the following conclusions are drawn. The within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithmetic achievement is not the same among children of low, average, and high intelligence; the average IQ children show less within-child variability than do the high and low IQ children who are equally variable. The truncated hypothesis is supported---the within-child variability in reading achievement, language achievement, and arithmetic achievement is the same among children of low, average, and high intelligence.

RELATIONSHIPS AMONG MEASURES[1]

The relationships among chronological age and 15 physical, mental, achieveme and personality measures were ascertained by correlational analysis with the children at a mean age of 113 months as of October 15, 1957. The same correlatio were computed with the children at a mean age of 125 months as of October 15, 195 In addition, in 1958 measures of handwriting and of friendship were secured and the correlations for these measures are also reported.

Table 57 shows the correlations among 16 measures for the 60 boys and 60 gir at a mean age of 113 months. Table 58 shows the correlations among 18 measures for the 60 boys and 60 girls at a mean age of 125 months. In each table and for each measure the upper row of correlations is for boys and the lower is for girls. Thus, in Table 57 the correlation between height and weight is .60 for boys, and .65 for girls. The correlation between height and grip is .47 for boys and .57 for girls.

Space does not permit a complete listing of all the correlations significant at or beyond the .01 level for the two years. The conclusions which follow give the main patterns of measures that are positively and significantly correlat and are based upon comparisons of the correlations for the two years.

[1] In this section r is often used instead of correlation, and after the first mention of mean months of age and corresponding year, the year or months of age are used interchangeably to save space and communicate efficiently.

TABLE 57

INTERCORRELATIONS AMONG SIXTEEN MEASURES FOR SIXTY BOYS AND SIXTY GIRLS AT 113 MONTHS OF AGE

**

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Height		60*	47*	18	49*	17	25	24	23	06	-14	-16	-20	08	07	-08
		65*	57*	05	68*	35*	29	35*	33*	-03	15	-03	28	03	-04	-01
2 Weight			41*	17	51*	14	15	11	09	04	-01	-12	-13	34*	39*	27
			45*	27	52*	11	03	08	06	07	12	-04	14	23	16	17
3 Grip				19	44*	39*	41*	40*	41*	18	-12	-05	-03	21	16	-05
				24	47*	50*	48*	52*	54*	01	39*	09	43*	10	-04	-05
4 Permanent teeth					24	-21	-12	-15	-11	-44*	10	16	13	08	08	16
					35*	-05	00	-03	01	06	-10	-04	00	02	-07	-12
5 Carpal						01	07	02	04	05	-20	-24	-25	16	14	-04
						22	20	20	19	15	-03	-10	03	-12	-16	-15
6 WISC IQ							93*	94*	93*	-05	-24	01	02	03	02	-08
							94*	96*	95*	-13	36*	17	38*	09	05	-27
7 Cal.reading								95*	96*	-04	-15	11	08	-05	-06	01
								94*	95*	-09	30	18	28	08	03	-26
8 Cal.arithmetic									96*	-05	-18	07	04	-03	-05	-01
									97*	-08	34*	16	40*	07	03	-24
9. Cal.language										-03	-18	12	07	-02	-04	-04
										-11	35*	19	40*	08	04	-24
10. Chronological age											13	11	23	-01	-07	06
											-07	-11	-04	-13	01	-13
11 Emotional adjustment												52*	72*	06	-15	28
												50*	71*	21	11	13
12 Achievement in relation to capacity													52*	-10	-08	28
													49*	17	15	25
13 Integration of self-concept														-08	-06	21
														26	19	11
14 Expression of emotion															77*	27
															81*	49*
15 Behavior pattern																33*
																40*
16 Child's estimate of abilities																

Decimal points have been dropped; the upper row on each variable is for boys, lower row is for girls. * Indicates an r siginificantly different from 0 at or beyond the .01 level; for significance at the .01 level, an r of .33 is required, at the .05 level, .25.

TABLE 58

INTERCORRELATIONS[1] OF 18 MEASURES FOR 60 LOW, AVERAGE, AND HIGH IQ BOYS AND 60 LOW, AVERAGE, AND HIGH IQ GIRLS AT 125 MONTHS OF AGE

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1** Height		66*	56*	13	51*	22	29	27	28	06	-11	03	-03	25	13	-19	17	01
		57*	56*	18	60*	27	24	25	24	04	-02	02	08	01	-01	11	25	08
2 Weight			50*	17	59*	08	15	10	06	05	-04	-08	-06	27	13	-05	04	-15
			40*	36*	55*	00	-02	00	03	17	03	-08	-11	13	08	22	00	-02
3 Grip				02	40*	30	32*	33*	28	10	10	00	09	44*	31	05	32*	00
				33*	50*	48*	38*	45*	46*	-09	19	30	35	08	-04	-07	42*	20
4 Permanent teeth					16	-23	-21	-24	-20	44*	03	-06	-07	18	13	-13	-16	13
					40*	06	09	07	16	10	11	11	16	06	-03	-03	21	-13
5 Carpal						-05	01	-04	-03	-05	-08	-17	-21	-02	-08	-16	00	-13
						14	11	08	09	10	-02	00	04	-06	-03	03	07	03
6 WISC IQ							95*	96*	94*	-04	-03	21	27	01	03	-08	80*	18
							95*	94*	94*	-26	26	50*	55*	03	01	-11	80*	21
7 Cal. reading								95*	96*	-07	00	28	28	00	03	-05	81*	18
								94*	96*	-19	21	48*	52*	-04	-07	-20	82*	13
8 Cal. arithmetic									96*	-05	-02	27	29	00	05	-06	85*	19
									97*	-13	23	45*	54*	03	-07	-20	84*	10
9 Cal. language										-04	-06	27	29	-06	00	-06	84*	22
										-18	25	47*	53*	02	-06	-21	84*	10
10 Chronological age											27	12	18	23	15	03	-03	01
											-11	-15	06	-10	-13	-02	-19	07
11 Emotional adjustment												58*	72*	35*	11	40*	-09	-05
												46*	47*	-06	-15	-19	22	29
12 Achievement in relation to capacity													75*	22	13	44*	15	38*
													67*	02	-12	18	46*	32*
13 Integration of self-concept														20	10	40*	19	19
														29	-01	07	47*	22
14 Expression of emotion															83*	28	-06	-01
															78*	52*	-06	-05
15 Behavior pattern																22	-03	-01
																41*	-15	01
16 Child's estimate of abilities																	-05	10
																	-19	23
17 Handwriting																		23
																		13
18 Sociometric																		

---

[1] Decimal points have been dropped; the upper row on each variable is for boys, lower row is for girls. *Indicates an r significantly different from 0 at or beyond the .01 level; for significance at the .01 level, an r of .33 is required, at the .05 level, .25.

1. In both years height, weight, grip, and carpal age are positively and significantly correlated for both sexes. Dentition correlates inconsistently and generally not significantly with the other four physical measures. Strength of grip correlates positively and generally significantly with IQ, reading achievement, arithmetic achievement, language achievement, and handwriting. The correlations between the physical measures and all other measures for both years are generally nonsignificant.

2. IQ, reading achievement, arithmetic achievement, language achievement, and handwriting correlate high, positively and significantly. The IQ and achievement measures do not correlate consistently with other measures except with strength of grip as noted previously, and with two personality ratings--achievement in relation to capacity and integration of self-concept.

3. Chronological age shows no significant r's with the other measures for either year except with boys' dentition. In setting up the study the researchers intended to secure a sufficiently harrow range in chronological age to secure nonsignificant r's with the other measures. The statistically significant r's between chronological age and number of permanent teeth for boys is interpreted as possibly a unique characteristic of dental development of this sample of boys.

4. Two main patterns of significant and positive r's emerge related to the personality ratings. Emotional adjustment, achievement in relation to capacity, and integration of self-concept correlate positively and generally significantly for both sexes for both years. Expression of emotion, behavior pattern, and the child's estimate of his own abilities also show positive and generally statistically significant r's for both sexes for both years. In addition, two of the personality variables, achievement in relation to capacity and integration of self-concept correlate positively and generally significantly with IQ, reading achievement, arithmetic achievement, language achievement, and handwriting, with the r's higher for girls than for boys.

5. Handwriting, as noted in the above conclusion, correlates positively, generally high, and significantly with IQ, reading achievement, arithmetic achievement, language achievement, strength of grip, achievement in relation to capacity, and integration of self-concept. It is interesting to note that the r's between handwriting and height, weight, permanent teeth, and carpal age are not significantly different from 0. Thus, the patterns for r suggest that not only are the physical measures other than grip not positively correlated with IQ, reading, arithmetic, and language achievement, they are also not correlated with handwriting. As noted previously, handwriting was used in this study as a measure of coordination.

6. Sociometric scores correlate positively and significantly only with integration of self-concept. This conclusion is applicable only to the average and high IQ children because the low IQ children were not included in computing the r's. The method of scoring the sociometric test with weighted scores permitted the low IQ children in small classrooms to receive as high scores as the average and high IQ children in regular classrooms.

It should be noted that the preceding six statements set forth the major res

of the correlational analyses for two years for both sexes. Some injustice is don

to the few additional r's reported in the two tables. In addition, the correlati among measures which are positively correlated with intelligence are somewhat higher than would be found in a normally distributed sample according to intelligen inasmuch as 20 boys and 20 girls are of low intelligence and 20 boys and 20 girls are of high intelligence leaving only 20 boys and 20 girls in the average IQ range. The r's among the first ten measures reported in Tables 57 and 58 were also computed for 40 boys and 40 girls randomly distributed according to WISC IQ. For these randomly drawn samples of 40 boys and 40 girls, normally distributed according to WISC IQ, the r's among IQ, reading, arithmetic, and language achievement ranged from .70 to .89 in 1957 and from .80 to .95 in 1958. Tables 57 and 58 for the 60 boys and girls show the ranges on the same variables to be from .93 to .97 in 1957 and .94 to .97 in 1958. Finally, the intercorrelations for the same measures are not reported for the 120 children according to the three IQ groups. In general, the same patterns emerge for the three IQ level groups, according to sex, as for the 60 boys and 60 girls. In addition, the difference among means for the three IQ groups are given in the next part of the report.

DIFFERENCES AMONG THE THREE IQ GROUPS IN VARIOUS MEASURES

For the 16 measures in 1957 and for the 18 measures in 1958 the significance of difference among means according to sex and IQ level was found. For each measure the analysis of variance was first run. Where a difference by IQ level significant at the .01 level was found the Tukey Test was run to compare the differences between means of the IQ groups.

Tables 59 and 60 give the means and standard deviations for each measure according to IQ group and sex in the first four columns, by IQ group with boys' and girls' scores combined in the next two columns, and for the 60 boys and 60 girl in the last two columns. In Table 59 it is seen that the mean height of the 20 lo IQ boys was 52.85 inches, of the average IQ boys 52.83, and of the 20 high IQ boys 54.00. The mean height of the 20 low IQ girls was 52.21, of the 20 average IQ girls 52.77, and of the high IQ girls 54.54. The mean height of the 40 low IQ

TABLE 59

MEANS AND STANDARD DEVIATIONS FOR SIXTEEN MEASURES OF 120 CHILDREN AT 113 MONTH OF AGE

VARIABLE	IQ	BOYS		GIRLS		40 Boys & Girls by IQ		60 Boys		60 Girls	
	Level	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1. Height	Low	52.85	3.08	52.21	1.88	52.53	2.55				
	Average	52.83	3.22	52.77	2.55	52.80	2.90	53.22	2.95	53.17	2.51
	High	54.00	2.31	54.54	2.44	54.27	2.37				
2. Weight	Low	68.61	12.41	67.40	12.22	68.00	12.31				
	Average	66.21	13.54	66.15	11.56	66.18	12.59	68.98	12.53	67.99	10.96
	High	72.12	10.76	70.42	8.25	71.27	9.58				
3. Grip	Low	15.99	3.46	12.99	2.07	14.49	2.85				
	Average	18.49	2.82	15.56	1.88	17.02	2.39	17.78	3.19	14.98	2.84
	High	18.87	2.39	16.39	3.16	17.63	2.80				
4. Dentition	Low	12.90	4.38	13.75	3.37	13.32	3.90				
	Average	12.60	2.18	13.90	2.95	13.25	2.59	12.28	3.20	13.75	2.80
	High	11.35	2.33	13.60	1.85	12.47	2.10				
5. Carpal	Low	107.85	14.24	109.85	12.17	108.85	13.24				
	Average	103.95	12.50	110.90	12.16	107.42	12.33	106.53	12.73	112.73	12.16
	High	107.80	10.83	117.45	10.69	112.62	10.76				
6. IQ	Low	66.35	6.27	63.55	4.75	64.95	5.56				
	Average	102.75	5.22	101.65	6.28	102.20	5.79	98.52	25.38	96.78	25.91
	High	126.45	5.86	125.15	4.44	125.80	5.19				
7. Reading	Low	80.95	4.09	83.65	5.72	82.30	4.97				
	Average	117.70	13.21	122.05	8.82	119.87	11.23	113.95	27.39	116.47	26.48
	High	143.20	10.09	143.70	11.97	143.45	11.07				
8. Arithmetic	Low	87.20	3.04	87.54	3.96	87.37	3.53				
	Average	113.20	6.70	113.45	4.76	113.32	5.81	108.95	17.08	107.68	15.30
	High	126.45	4.91	122.05	4.37	124.25	4.69				
9. Language	Low	80.00	8.64	85.25	7.81	82.92	8.23				
	Average	120.55	10.32	126.85	8.85	123.70	9.62	113.78	26.71	118.38	24.99
	High	140.80	6.53	142.45	5.05	141.62	5.83				

Continued on next page.

TABLE 59, Continued

MEANS AND STANDARD DEVIATIONS FOR SIXTEEN MEASURES OF 120 CHILDREN AT 113 MONTHS OF AGE

VARIABLE	Level	BOYS Mean	BOYS S.D.	GIRLS Mean	GIRLS S.D.	40 Boys & Girls by IQ Mean	40 Boys & Girls by IQ S.D.	60 Boys Mean	60 Boys S.D.	60 Girls Mean	60 Girls S.D.
10. Chronological	Low	113.05	4.63	112.75	4.21	112.90	4.42				
Age	Average	112.75	3.99	113.00	4.03	112.87	4.01	112.77	4.01	112.32	4.12
	High	112.50	3.27	111.20	3.86	111.85	3.58				
11. Emotional	Low	4.46	1.71	3.96	1.28	4.21	1.51				
Adjustment	Average	3.94	1.18	4.39	1.71	3.96	1.47	3.95	1.54	4.51	1.62
	High	3.86	1.56	5.18	1.61	4.52	1.58				
12. Achievement in	Low	4.22	1.33	4.74	1.18	4.48	1.26				
Relation to	Average	4.07	1.29	4.98	1.29	4.52	1.29	4.22	1.22	4.96	1.25
Capacity	High	4.39	1.00	5.15	1.25	4.77	1.33				
13. Integration of	Low	4.25	1.52	4.11	1.35	4.18	1.43				
Self-Concept	Average	4.09	1.56	5.59	1.41	4.84	1.48	4.27	1.61	5.03	1.64
	High	4.48	1.72	5.39	1.72	4.93	1.72				
14. Emotional	Low	5.51	1.85	5.34	2.09	5.42	1.97				
Expression	Average	4.86	1.84	5.35	1.62	5.10	1.73	5.33	1.76	5.47	1.86
	High	5.66	1.46	5.73	1.76	5.69	1.61				
15. Behavior Pattern	Low	5.75	1.69	5.21	1.82	5.48	1.75				
	Average	4.94	1.74	5.06	1.46	5.00	1.60	5.45	1.66	5.20	1.55
	High	5.68	1.41	5.33	1.30	5.50	1.35				
16. Estimate of	Low	4.81	1.65	5.72	1.79	5.26	1.72				
Own Ability	Average	4.33	1.01	4.88	1.11	4.60	1.06	4.62	1.25	5.13	1.40
	High	4.73	0.89	4.80	0.94	4.76	0.91				

TABLE 60

MEANS AND STANDARD DEVIATIONS FOR EIGHTEEN MEASURES OF 120 CHILDREN AT 125 MONTHS OF AGE

VARIABLE	IQ Level	BOYS Mean	BOYS S.D.	GIRLS Mean	GIRLS S.D.	40 Boys & Girls by IQ Mean	40 Boys & Girls by IQ S.D.	60 Boys Mean	60 Boys S.D.	60 Girls Mean	60 Girls S.D.
1. Height	Low	54.0	2.5	54.5	1.8	54.2	2.2				
	Average	54.5	3.4	55.2	2.6	54.9	3.1	54.7	2.8	55.2	2.5
	High	55.6	2.2	56.0	2.6	55.8	2.4				
2. Weight	Low	74.8	15.5	75.9	12.3	75.3	14.0				
	Average	75.5	16.6	73.7	13.4	74.6	15.1	75.9	14.0	75.3	12.0
	High	77.6	8.1	76.4	9.9	77.0	9.0				
3. Grip	Low	18.4	3.9	14.5	2.5	16.5	3.8				
	Average	20.8	3.7	17.2	2.4	19.0	3.6	20.1	3.6	16.4	3.2
	High	21.1	2.5	17.7	3.4	19.4	3.5				
4. Dentition	Low	15.7	4.7	15.7	4.3	15.7	4.5				
	Average	15.1	4.2	17.2	4.9	16.1	4.7	14.5	4.2	16.4	4.5
	High	12.9	2.9	16.3	4.1	14.6	3.9				
5. Carpal	Low	121.4	14.0	123.5	11.7	121.4	13.0				
	Average	116.8	13.9	123.0	8.1	119.9	11.8	119.9	12.9	124.5	9.5
	High	121.5	9.8	127.1	7.6	124.3	9.2				
6. IQ	Low	69.1	7.1	64.7	6.8	66.9	7.3				
	Average	106.9	5.1	103.4	7.0	105.2	6.4	101.5	25.5	99.0	27.3
	High	128.7	7.8	129.0	7.0	128.9	7.4				
7. Reading	Low	85.9	5.6	89.9	8.2	87.9	7.3				
	Average	130.4	10.3	135.3	12.1	132.8	11.5	125.4	31.6	127.7	29.8
	High	159.9	9.7	158.0	7.4	158.9	8.7				
8. Arithmetic	Low	93.2	4.5	91.4	4.5	92.3	4.6				
	Average	124.8	5.4	125.1	6.7	124.9	6.1	118.1	18.9	116.6	18.9
	High	136.3	5.1	133.5	4.0	134.9	4.8				
9. Language	Low	87.0	9.8	89.6	7.5	88.3	8.8				
	Average	126.8	7.0	134.3	11.3	130.5	10.1	120.2	25.9	124.2	26.6
	High	146.8	5.5	148.7	7.1	147.7	6.4				

Continued on next page

TABLE 60, Continued

MEANS AND STANDARD DEVIATIONS FOR EIGHTEEN MEASURES OF 120 CHILDREN AT 125 MONTHS OF AGE

VARIABLE	IQ Level	BOYS		GIRLS		40 Boys & Girls by IQ		60 Boys		60 Girls	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
10. Chronological Age	Low	124.8	4.4	125.1	4.2	125.0	4.3				
	Average	124.5	4.0	124.9	3.8	124.7	3.9	124.6	3.9	124.3	3.9
	High	124.6	3.2	122.9	3.3	123.7	3.3				
11. Emotional Adjustment	Low	4.2	1.3	4.3	1.2	4.2	1.1				
	Average	4.0	1.2	4.7	1.2	4.3	1.2	4.1	1.2	4.6	1.2
	High	4.1	1.3	5.0	1.0	4.5	1.2				
12. Achievement in Rel.to Capacity	Low	4.0	1.0	4.2	1.0	4.1	1.0				
	Average	3.9	1.0	4.6	1.1	4.2	1.1	4.2	1.1	4.8	1.1
	High	4.8	1.1	5.6	0.6	5.2	0.9				
13. Integration of Self-Concept	Low	4.0	1.4	3.9	1.3	4.0	1.4				
	Average	4.4	1.2	5.4	1.2	4.9	1.3	4.5	1.4	5.0	1.4
	High	5.1	1.5	5.8	1.0	5.4	1.3				
14. Emotional Expression	Low	5.0	1.7	5.1	1.5	5.0	1.6				
	Average	5.0	1.7	5.0	1.4	5.0	1.6	5.0	1.6	5.1	1.4
	High	4.9	1.3	5.2	1.4	5.1	1.4				
15. Behavior Pattern	Low	5.0	1.6	5.3	1.5	5.1	1.5				
	Average	5.3	1.4	4.6	1.3	4.9	1.4	5.1	1.5	5.1	1.3
	High	5.2	1.3	5.4	0.9	5.3	1.1				
16. Estimate of Own Ability	Low	4.4	1.1	4.9	0.9	4.7	1.0				
	Average	4.0	1.1	4.1	1.1	4.0	1.1	4.2	1.1	4.5	1.0
	High	4.3	1.0	4.7	0.9	4.5	1.0				
17. Handwriting	Low	18.5	8.7	23.6	13.2	21.1	11.5				
	Average	50.7	13.1	56.1	14.6	53.4	14.1	43.5	21.9	47.1	20.7
	High	61.4	14.1	61.7	7.6	61.5	11.3				
18. Sociometric	Low	15.9	7.2	13.9	8.2	14.9	7.8				
	Average	15.1	9.1	11.9	9.0	13.5	9.2	17.3	9.7	14.5	9.6
	High	20.9	11.3	17.8	10.6	19.3	11.1				

TABLE 61
SUMMARY OF SIGNIFICANT DIFFERENCES AMONG MEAN SCORES BY IQ LEVEL AND SEX BASED ON ANALYSES OF VARIANCE AND THE TUKEY TESTS FOR COMPARISON OF MEANS

MEASURE	1957 RESULTS AT 113 MONTHS OF AGE –	1958 RESULTS AT 125 MONTHS OF AGE –
Height	The high IQ group is taller than the average and the low.	No significant differences by sex or IQ level.
Weight	There is no significant difference among means by sex or IQ level.	No significant differences by sex or IQ level.
Grip	The low IQ group is weaker than the average and the high; the average group is weaker than the high; girls are weaker than boys.	The low IQ group is weaker than the average and high; girls are weaker than boys.
Dentition	Girls have more permanent teeth than boys.	No significant differences by sex or IQ level.
Carpal	Girls' carpal age is higher than boys.	No significant differences by sex or IQ level.
Reading	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.
Arithmetic	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.
Language	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.	The low IQ group mean is lower than the average and the high group; the average group is lower than the high.

Continued on next page.

TABLE 61, Continued

SUMMARY OF SIGNIFICANT DIFFERENCES AMONG MEAN SCORES BY IQ LEVEL AND SEX BASED ON ANALYSES OF VARIANCE AND THE TUKEY TESTS FOR COMPARISON OF MEANS

MEASURE	1957 RESULTS AT 113 MONTHS OF AGE	1958 RESULTS AT 125 MONTHS OF AGE
Emotional adjustment*	There is no significant difference among means by sex or IQ level.	No significant differences by sex or IQ level.
Ach. and capacity*	Girls achieve higher in relation to capacity than boys.	Girls achieve higher in relation to capacity than boys. The low IQ group mean is lower than the high; the average IQ group mean is lower than the high.
Int. self-concept*	No difference by sex or IQ level is significant at the .01 level; girls' mean score is higher at the .02 level.	The low IQ group mean is lower than the average and the high group.
Emotional expression*	There is no significant difference by sex or IQ level.	No significant differences by sex or IQ level.
Behavior pattern*	There is no significant difference by sex or IQ level.	No significant differences by sex or IQ level.
Est. of own ability*	There is no significant difference by sex or IQ level. (Girls' mean score is significantly higher at about .02 level)	The average IQ group mean is lower than the low IQ group.
Handwriting	Difference not tested at 113 months of age.	The low IQ group mean is lower than the average and the high group.
Sociometric**	Difference not tested at 113 months of age.	No significant differences by sex or IQ level.

* Based upon psychologists' estimates.

** Comparison made between average and high IQ; the low IQ Ss were excluded from this analysis.

boys and girls combined was 52.53, of the 40 average IQ boys and girls was 52.80, and of the 40 high IQ boys and girls 54.27. The mean height of the 60 boys was 53.22, and of the 60 girls 53.17.

As was stated previously, a separate analysis of variance was run on each measure to ascertain significant differences between the two sexes and among the three IQ groups. Spaced does not permit inclusion of the 34 tables that are needed to show the results of the analysis of variance nor of the subsequent tables required to show each separate Tukey Test. Therefore, Table 61 is presented which gives all the differences between the two sex groups and the three IQ groups significant at or beyond the .01 level. Chronological age and WISC are not included, for by the design of the study, chronological age was equal for the three IQ groups and for boys and girls; whereas IQ was equal for boys and girls but greatly different among the three IQ groups.

In the left column of Table 61 the results are given for the children at 113 months of age, and in the right column for the children at 125 months of age. It is seen in Table 61 that at 113 months of age, the high IQ group was significantl taller than the average and low IQ. No other differences in height are reported as significant. This should be interpreted to mean that the difference in height between boys and girls was not statistically significant and that the difference between the average and low IQ children was not statistically significant All other statements in Table 61 are to be interpreted in like manner.

In summary of the results presented in Table 61, nine conclusions are stated to assist in the proper interpretations of the table.

1. At both 113 and 125 months of age, there was no significant difference among the three IQ groups in six measures---weight, number of permanent teeth, carpal age, emotional adjustment, emotional expression, and behavior pattern. The groups of children were alike in these measures.

2. At both 113 and 125 months of age, the low IQ children were significantly lower than the average and high IQ children in four measures---strength of grip, reading achievement, arithmetic achievement, and language achievement. (At 125 months of age, the difference in grip between the average and high IQ children did not quite reach the .01 level.)

3. At 113 months of age there was no difference in achievement in relation to capacity; but at 125 months of age the low IQ children were lower than the average and the high IQ children, and the average IQ children were lower than the high IQ.

4. At 113 months of age there was no difference in integration of self-concept; but at 125 months of age the low IQ children were lower than the average and the high IQ children who were the same.

5. At 113 months of age the high IQ children were taller than the average and low IQ who were equal, but at 125 months of age there was no difference among the three groups.

6. At 113 months of age there was no difference among the three groups in the child's estimate of his own abilities but at 125 months of age the average IQ childfen were significantly lower than the low IQ children.

7. At 125 months of age there was no difference among the three IQ groups in sociometric scores; however, only the average and high IQ groups and boys and girls were compared.

8. At 125 months of age, the low IQ children had lower handwriting speed tha the average and high IQ who had equal speed.

9. At 113 months of age, significant differences between mean scores of the 60 boys and 60 girls were found in four measures---Girls had lower grip scores. more permanent teeth, higher carpal age, and achieved higher in relation to capaci than the boys. No other differences were significant at the .01 level. At 125 months of age, the only significant differences were in two measures---girls had lower strength of grip and achieved higher in relation to capacity than boys. Thus the boys caught up, or nearly so, to the girls in number of permanent teeth and carpal age.

The results, along with the design of the study, are discussed further in the next part.

V. DISCUSSION

In this section the methods used and the results obtained are discussed according to three main topics: Hypotheses 1 and 2 dealing with acquisition and retention; Hypotheses 3, 4, and 5 dealing with physical development and within-child variability; and the differences among children of low, average, and high intelligence in physical, achievement, personality, sociometric and handwriting measures.

HYPOTHESES 1 AND 2 DEALING WITH ACQUISITION AND RETENTION

The design to deal with acquisition and retention among children of low, average, and high intelligence differs markedly from any previous design the researchers have encountered in studies of retention. The main differences are that in the present study the subjects represent three distinct IQ levels, only socially useful arithmetic learnings were used, and the learning task was graded to each child's present achievement level, except in the common problem-solving task. Since socially useful arithmetic learnings were used rather than nonsense materials, the usual methods of measuring retention of nonsense material such as reproduction, recall, recognition, and anticipation were not applicable. Because socially useful arithmetic learnings were used, the child could practice between the 5-minute and subsequent 6-week and 12-week retention tests. Thus, some efficiency may have been lost if the use of nonsense material actually prevents practice between acquisition and retention measures. However, during the 5-minute interval between acquisition and the first retention measure in the present study, the researchers had the child under their jurisdiction. Since the results of the study were the same for the 5-minute interval between acquisition and retention and for subsequent intervals after acquisition, the researchers assume that if practice occurred, its incidence and effects were equal among the three IQ groups.

The use of learning tasks graded to the child's present achievement level tells us much about retention in school children. The researchers believe that studies of retention based on subjects acquiring (a) generally meaningless material, or (b) by rote methods, or (c) over short time spans as reported through the years by Ebbinghaus (1885), Luh (1922), Postman (1948), and Archer (1953) have offered little for understanding of school learning situations or retention in human beings more generally.

The investigation of retention among the three IQ groups is similar but not identical to the approach used by Dietze (1931) and Grant (1932). They studied the relationship between intelligence and retention in practical and nonsense verbal and numerical learning tasks using correlational techniques and a normally distributed range of subjects by IQ. However, the learning materials were the same for all the children, and hence, as expected, positive and significant correlations are reported between intelligence and retention.

Speed of learning arithmetic in the present study was inferred from the children's standardized achievement test scores and from the levels at which they worked problems in the various survey tests, but was assessed directly in the common problem-solving task used in testing Hypothesis 1. In Hypothesis 2, speed of learning was not considered except within the practical time limit imposed to complete the teaching-learning sequence with each child. Rather than emphasizing speed in the counting, addition, subtraction, and differentiated problem-solving tasks, the researchers intended to get the tasks graded to each child's level of achievement so that speed would not be a crucial factor, so that children within the various IQ levels would have opportunity to learn the tasks equally well. In turn, the results obtained are not directly comparable with the many previous studies which compare retention between fast and slow learners as represented in such studies as Gillette (1936), Leavitt (1945), Gilliland (1948), Zimny (1949), Underwood (1954), and Rustebakke (1954). The results reported by the above six investigators are highly inconclusive, in part because the same generally meaningless material was used to identify fast and slow learners. The researchers found that the common problem-solving task (Hypothesis 1) was quite meaningless for the lowest performing low IQ children but believe that all other tasks were quite meaningful for all the children. In turn, the researchers would have littl confidence in the results dealing with the inverse relationship between speed of learning and retention (Hypothesis 1) had not these results also been substantiated in the four subsequent tests of Hypothesis 2.

The present research was concerned with investigating learning and retention of socially useful and potentially meaningful material over longer periods of time similar to that studied by Spitzer (1939) and Hall (1955). Koffka (1935) proposed that the learning of nonsense syllables is anything but the normal case of learning, and suggested further that nonsense material is devoid of meaning which encourages retention. In a similar vein, Ausubel (1953) proposed that researchers dealing with educational problems should direct their efforts toward clarifying the nature of the long-term acquisition and retention of a stable body of ideas, concepts, facts, values, habits, skills, ways of perceiving, adjusting, and aspiring, and of the capacities needed for acquiring them. Prior to Ausubel, Harlow (1949), after establishing the fact of learning sets in laboratory animals proposed that the idea of learning set was highly important in understanding all adaptive behavior. Harlow also indicated high hope that the limited data he had provided would be extended by those researchers who study human beings. He subsequently proposed that, if the excellent controls possible in the animal laboratory could not be so finely managed with human subjects in non-laboratory setting departures in design as necessary should be made in studying human learning. The present investigators attempted to set up their design to achieve purposes proposed by Ausubel and Harlow. The researchers believe that one of the most significant outcomes from this study is the validity of the design for measuring retention over varying time intervals with subjects of three levels of intelliger whose task to be learned and retained is graded to his achievement level.

The results of the tests of the hypotheses are shown in Table 62. It is seen that Hypothesis 1 is rejected. The conclusion here is that speed of acquirir arithmetic learning is not inversely related to retention among groups of children of low, average, and high intelligence. Rather, there is no difference in the ratio scores between acquisition and retention among the three IQ groups. Similarly, Hypothesis 2 was accepted: there is no difference among children of low, average, and high intelligence in retention of arithmetic learning when the learning task is graded to each child's achievement level. Four socially useful and potentially meaningful acquisition-retention tasks in arithmetic -- counting, addition, subtraction, and differentiated problem-solving -- were used in testing the hypothesis and the results were the same for all tasks at all time intervals with varying conditions in the teaching-learning procedure.

Table 62 shows also that the researchers were partially successful in grading the counting and addition tasks to make them equally difficult for the three IQ groups. The acquisition task in counting was more difficult for the low IQ children than for the average or high IQ children for whom it was equally difficult. The acquisition task in addition was more difficult for the average IQ children than for the high IQ children, but equally difficult for the low and high IQ children. As Table 62 shows, the researchers were successful in arrangin the subtraction and differentiated problem-solving tasks to be equally difficult for children according to the three IQ levels. Since analysis of covariance had

TABLE 62

SUMMARY OF ACCEPTANCE OR REJECTION OF HYPOTHESES 1 AND 2
DEALING WITH ACQUISITION AND RETENTION

Measure Used and Hypothesis Tested	Acquisition 5-Min. Ret.	Acquisition 6- or 7-Wk. Retention	Acquisition 12- or 14-Wk. Retention	Graded Level Difficulty
Common Problem-Solving (1)	Rejected	Rejected	Rejected	Not tested
Counting (2)	Accepted	Accepted	Not tested	More difficult for Low IQ than for Av. or Hi IQ
Addition (2)	Accepted	Accepted	Not tested	More difficult for IQ than for Hi IQ
Subtraction (2)	Accepted	Accepted	Accepted	Equally difficult f all three IQ groups
Differentiated Problem-Solving (2)	Accepted	Accepted	Not tested	Equally difficult f all three IQ groups

been used on the first two tasks and since high correlations were found between acquisition and 5-minute retention scores, analysis of covariance was also used in analyzing the subtraction and differentiated problem-solving data.

Would the same results have been obtained in another area of learning in the cognitive domain, for example, vocabulary, reading, science concepts, or social studies concepts? The researchers think so. They have high confidence in the results and suggest that one of the most important implications of the entire study is that classroom teachers should find out the present achievement level of the child. Upon ascertaining this and knowing learnings at next higher levels of difficulty, the teacher should offer individualized instruction or arrange the children in smaller groups as necessary to provide instruction which will encourage efficient acquisition and subsequent retention.

The levels at which the children of low, average, and high intelligence worked in counting, adding, subtracting, and differentiated problem-solving were shown in the results section. The difference between the average and high IQ children was not so great as the researchers had anticipated. Particularly in in addition and subtraction every high IQ child achieved at a level above that in which he had thus far received formal instruction in his classroom. Further, most of the average IQ children were also above the level at which they had received formal instruction in the classroom. These children did not get formal classroom instruction on the particular task during the six- and twelve-week intervals between the acquisition and retention measures. The researchers do not conclude that the high IQ children should be advanced more rapidly than they are in arithmetic. They positively conclude, however, that the high IQ children can learn and retain arithmetic learnings considerably beyond those which are now included in their curriculum. For example, while not a single high IQ child had received instruction in subtracting mixed numbers with borrowing, the researchers found that in 10 to 17 minutes the high IQ child learned this process very efficiently and subsequently performed well after 5 minutes, 6 weeks, and 12 weeks without further instruction.

The researchers also had not anticipated finding the wide range in arithmetic performance among the low IQ children. When the low IQ children were at a mean age of 101 months they appeared to have difficulty in grasping the most simple quantitative concept such as "more" and "less," "higher" and "lower." At 113 months of age many of the low IQ children showed a marked increase in ability to understand numbers and other quantitative concepts. At 125 months of age some of the children acquired new arithmetic learnings with considerable facility. Thus, as was shown previously, at 113 months of age as of October 15, 1958, seven low IQ children added exercises of two addends, two digits each, and carrying. A year later, two low IQ children subtracted exercises involving two digits, minuends and subtrahends, and borrowing. The researchers believe that somewhere around the age of 110 to 120 months, low IQ children with IQs of 55 to 80 can acquire arithmetic learnings quite efficiently if the learnings are graded to each child's achievement level.

HYPOTHESES 3, 4, AND 5 DEALING WITH PHYSICAL DEVELOPMENT AND WITHIN-CHILD VARIABILITY

The results of the test of Hypotheses 3, 4, and 5 are shown in Table 63. Hypothesis 3 — uneven physical development within the child accompanies low achievement in arithmetic and reading — was rejected in 1956, 1957, and 1958 for both sexes, but always the correlations were negative in the hypothesized direction.

Hypothesis 4 — a low level of physical development within the child accompanies low achievement in arithmetic and reading — was upheld for boys and rejected for girls in 1956. It was rejected for both sexes in 1957 and in 1958. Therefore, except with children at the youngest age and only for boys, no significant relationship was found between the levels of physical development in four measures — height, weight, strength of grip, and carpal age — and achievement in either reading or arithmetic.

Hypothesis 5 — the within-child variability in grip, IQ, reading, arithmetic,

TABLE 63

SUMMARY OF ACCEPTANCE AND REJECTION OF HYPOTHESES 3, 4, AND 5 DEALING WITH DEVELOPMENT AND WITHIN-CHILD VARIABILITY AND CONCERNING RELATIONSHIPS AMONG PHYSICAL AND MENTAL ACHIEVEMENT MEASURES IN CHILDREN OF LOW, AVERAGE AND HIGH INTELLIGENCE

Hypothesis	1956 101 months old	1957 113 months old	1958 125 months old
(3) Uneven physical development with the child (split growth) accompanies low achievement in arithmetic and reading.	Rejected, but all correlations are negative, the hypothesized direction.	Rejected, but all correlations are negative, the hypothesized direction.	Rejected, but all correlations are negative, the hypothesized direction.
(4) A low level of physical development within the child accompanies low achievement in arithmetic and reading.	Uphold for boys. Rejected for girls.	Rejected for both sexes.	Rejected for both sexes.
(5) The within-child variability in grip, IQ, reading, arithmetic, and language achievement is the same among children of low, average, and high intelligence.	Rejected on the basis of comparison of means.	Rejected.	Rejected.
(5_a) The within child variability in the three achievement measures is the same among children of low, average, and high intelligence.	Upheld.	Upheld.	Upheld.

and language achievement is the same among children of low, average, and high intelligence — was rejected in 1956 on the basis of comparing the means of the three IQ groups. In 1957 and 1958 it was rejected by tests of analysis of variance. Thus, the within-child variability in these measures is not the same. In each case the average IQ children showed less within-child variability than did the low and high IQ children -- the levels at which the average IQ children were performing in the five functioning areas were most consistent. This conclusion does not result from the possibility that the within-variance of the average IQ children as a group in each of the five measures was less than the within-variance of the other two groups in each of the five measures. The standard deviations (Table 59) from which the within-variance can be easily determined showed the average IQ children as a group to have a higher but not statistically significant standard deviation than either the high or low IQ in four of the five measures used in testing the hypothesis: IQ, reading achievement, arithmetic achievement, and language achievement.

As noted before, Hypothesis 4 was rejected; also strength of grip correlated higher with reading and arithmetic achievement than did the composite measure of the level of physical development. The addition of height, weight, and carpal age to grip resulted in a lower correlation than that obtained between grip separately and the achievement measures. Also, number of permanent teeth was found not to correlate significantly with any other measure in the study. This finding, and findings to be reported subsequently, is accepted by the researchers as conclusive proof that Olson's (1949) procedure of weighting the physical measures equally with reading age and mental age in attempting to understand a child's difficulties or successes in school is invalid. Further substantiation of the invalidity of weighting the physical measures equally with mental age and reading age is now given. Sontag, Nelson, and Baker (1958) reported a longitudinal study and concluded that there was no relationship between physical growth rate and mental growth rate during late preschool and early school years, from about four to eight years of age. Klausmeier, Beeman, and Lehmann (1958) found that the physical measures — height, weight, grip, number of permanent teeth, and carpal age — contributed practically nothing to mental age and reading age in predicting fourth grade achievements of third grade children or sixth grade achievements of fifth grade children, thus accounting for the age group from approximately 9 to 12. Blommers, Knief, and Stroud (1956), using a technique different from Sontag and Klausmeier, came up with the similar conclusion that weighting physical measures equally with mental measures in an attempt to understand a child's school achievements was not a useful procedure. These conclusions are pertinent only up to age 12, and in no way deny the possibility that maturity as measured by carpal X-rays of the hand and wrist may not subsequently influence behavior and learning of adolescents as is reported by Bayley (1956) and Ames (1957). It should be noted, however, that at a mean age of 125 months, some children in the present study already have 28 teeth. Obviously, dentition as a measure of development can no longer be used with these children, further invalidating the idea of counting number of permanent teeth equally with mental age in predicting or understanding a child's achievement in arithmetic.

While the correlations were low and not statistically significant between uneven physical development and achievement in reading and arithmetic, they were all negative. It is possible that the period of development from 101 to 125 months of age is characterized by unevenness in the physical measures rather than evenness. Gleason and Klausmeier (1958) also found a consistent negative correlation between uneven physical development and achievement in reading, arithmetic, and language. Similarly, Enos (1958) reported low negative correlations between uneven physical development and emotional adjustment, that is, the children most uneven in the physical measures also tended toward emotional maladjustment.

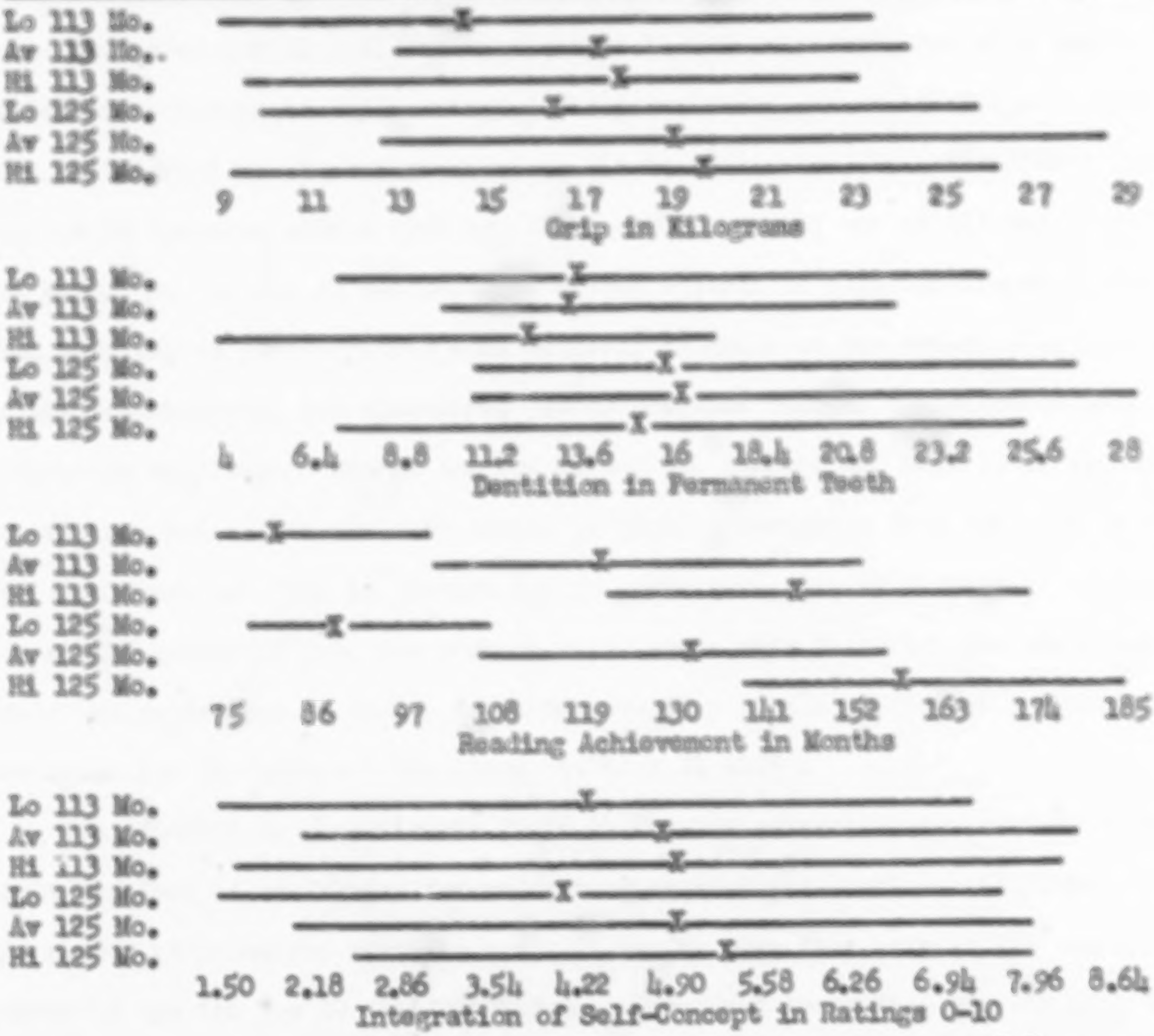
DIFFERENCES AMONG IQ GROUPS IN PHYSICAL, ACHIEVEMENT, PERSONALITY, AND SOCIOMETRIC MEASURES

Both the correlations among the measures and the differences among means were reported in the results section. The researchers assume that the correlations are self-explanatory and, therefore, discuss them no further. Concerning the differences found among the groups, only the major conclusions are restated and discussed. Four measures — grip, reading achievement, arithmetic achievement, and language achievement — differentiate among the three IQ groups reasonably well at 113 months of age but somewhat better at 125 months of age. Six measures — weight, permanent teeth, carpal age, emotional adjustment, emotional expression, and behavior pattern — do not discriminate among the IQ groups. Integration of self-concept, achievement in relation to capacity, and the child's estimate of his own ability, and height discriminate between two IQ groups at one or both ages, and handwriting speed does at 125 months. By discriminating is meant that the differences among or between IQ groups was found to be statistically significant. At this time, the researchers offer an interpretation of statistical significance in relation to practical significance.

Table 64 is a graphic presentation of the ranges and mean scores for grip, dentition, reading achievement, and integration of self-concept for the low, average and high IQ children at 113 and 125 months of age. As well as can be

TABLE 64

GRAPHIC PRESENTATION OF RANGES AND MEAN SCORES FOR GRIP, DENTITION, READING ACHIEVEMENT, AND INTEGRATION OF SELF-CONCEPT FOR LOW, AVERAGE, AND HIGH IQ CHILDREN, 1957 and 1958



transmitted by the means of reproducing this table, the four measures are all presented in the same ratio, the difference between the lowest score and highest score in each of the four measures is contained in the same horizontal distance.

Table 64 shows a vast amount of overlap among the scores in grip for the three IQ groups. It also shows, however, that the means for the average and high IQ children for both years are considerably above the means of the low IQ group for both years. Thus, despite the overlap, securing strength of grip might be useful in attempting to understand a child's total developmental pattern. Correlations between strength of grip and the achievement measures, IQ, and handwriting were also found to be positive and high. Strength of grip is the only measure of vitality used in this study. Throughout the study, the researchers noted that some low IQ children appeared to be not only weak, but also unable to muster and concentrate their energy for any sustained period of time on a task such as handwriting or problem-solving. It is interesting to note further that the low IQ children gained from age 113 to 125 months of age as did the average and high. As the low IQ children get better control of their environment with age, they may be participating more actively in games on the school playground, in the neighborhood, and elsewhere. It is possible that as the children grow older, the difference between the low IQ and the average and high IQ in strength of grip may become increasingly small. A final observation from Table 64 is that one should not use grip to predict the IQ or achievements of individual children; for at 125 months of age, the weakest child was a high IQ child, the strongest child was an average IQ child, and there was very little difference between the strongest low IQ child and the strongest high IQ child.

The material on dentition in Table 64 further substantiates previous comments about its lack of usefulness for understanding anything about a child other than the number of permanent teeth he has. It may be seen that both at 113 and 125 months of age the low IQ children had more permanent teeth than did the high IQ children.

As shown in Table 64, reading achievement discriminates with a high degree of precision between the low and the average IQ children and also relatively well between the average and high IQ children. The highest low IQ child did not achieve as high in reading as the lowest average IQ child. Further, the highest average IQ child was little above the lowest high IQ child. Thus, while there was a statistically significant difference among the three IQ groups both in grip and in reading achievement, the difference in reading achievement carries more practical significance in that it discriminates among the groups far more efficiently.

Integration of self-concept was one of the measures in which differences among the IQ groups were noted as being significant at 125 months of age with the mean for the low IQ children significantly lower than the means for the average and high. Differences among the three IQ groups were noted in 1957 at 113 months of age, but none were significant whereas an emerging pattern of greater differences with increasing age is noted in 1958. Table 64 shows why this conclusion was drawn. It can be seen that there is much overlap among the three IQ groups at both ages; however, the difference between the low and the average group is considerably greater at 125 than it was at 113 months, and also the difference in mean rating between the average and high IQ children is greater at 125 than at 113 months. Of considerable practical significance is the fact that in integration of self-concept, the low IQ children are lower at 125 months than at 113, and the spread between them and the other children is increasing.

The above discussion has treated differences within children of the same IQ group though the major comparisons were made by groups. The principal application of the measures for each child was made by reporting the scores and other information to the school system annually. Also, when a child was found to need attention urgently by the medical examination, dental examination, or psychological assessment, the building principal was immediately informed. The information provided to the schools was of as much or more practical significance as were the differences among means of the three groups. For good educational provisions and for understanding each child's behavior and development, individual differences must be recognized as above and also as reported by Bayley (1956) and Harris and Bereiter (1959).

A few additional comparisons of the results of this study with other studies are in order. As also found by Francis and Rarick (1959), the correlations among physical and achievement measures were much the same for the low IQ children as for the average and high IQ children. Gallagher (1958) reported that gifted children were well accepted by other children in elementary classrooms. The same result was found in this study; further, friendships among the low IQ children in special classes for the mentally retarded were found not to vary markedly from those for the average and high IQ children in regular classrooms.

A note of caution is in order. It was shown previously that the correlations between the ratings of the psychologist who did the examining and the subsequent independent ratings of a second psychologist were low on three variables — pattern of behavior, emotional expression, and the child's estimate of his own abilities. If one used the examiner's ratings of the child he would arrive at somewhat different conclusions from those arrived at from using the second psychologist's rating. Apparently seeing and being with the child influenced the examiner's ratings on these variables. Though this is the case, one would come up with the same sort of discrepancy about the emotional adjustment of particular children if he used any one of the three most commonly used paper-pencil personality tests: California Test of Personality, Rosenzweig Picture Frustration Study, and Roger's Test of Personality Adjustment. Smith (1958), having administered these three tests to the same group of children and also three recently unpublished tests, found that no two tests consistently placed children in the best adjusted or most poorly adjusted group. The researchers are not predicting that all children who showed poor emotional adjustment and poor integration of self-concept in the present study will show similar patterns three or five years hence. Beilin (1957) predicted the behavior of children and adolescents four years hence based upon present measures and ratings. He found low correlations between the original ratings and subsequent adjustment of the children and adolescents as based upon quite reliable objective criteria.

VI. SUMMARY

Efficiency of learning and retention and the relationships among various physical, achievement, and personality measures in mentally retarded children are of significance to society generally, to those responsible for the education of mentally retarded children, to those concerned with theory of school learning and behavior, and to those interested in the science of individual differences. This study of mentally retarded children also included children of average and high intelligence as control groups, thus extending the scope of its possible significance. The main purpose of the study was to test the five hypotheses listed below, and the secondary purpose was to ascertain the relationships among measures purportedly related to school success and personality development and to ascertain differences among the three IQ groups in the measures:

1. Speed of acquiring arithmetic learning is inversely related to retention among groups of children of low (IQ 55 to 80), average (IQ 90 to 110), and high intelligence (IQ 120+). This hypothesis implies that high IQ children learn rapidly and forget rapidly, whereas low IQ children learn slowly and forget slowly.

2. Retention of arithmetic learning is the same among children of low, average and high intelligence when the original learning task is graded to the learner's achievement level.

3. Uneven physical development (split growth) within the child accompanies low efficiency in arithmetic achievement and in reading achievement.

4. A low level of physical development within the child accompanies low achievement in arithmetic and reading.

5. The within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithmetic achievement is the same among children of low, average, and high intelligence. Stated differently, the low IQ children as a group are equally low within themselves in all five measures, the average IQ are equally average, and the high IQ are equally high. A truncated hypothesis is that the within-child variability as shown in reading achievement, language achievement, and arithmetic achievement is the same among children of low, average, and high intelligence.

The secondary purpose of the investigation was to ascertain the relationships among the physical, achievement, and personality measures, and the differences among the three IQ groups in each of the measures.

Specialized acquisition-retention tasks in common problem-solving, counting, addition, subtraction, and differentiated problem-solving were developed and administered to each child to test Hypotheses 1 and 2 during the 1957-58 and

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pupils were added.

A medical examination was given to each child during the 1957-58 school year, and the examining physician rated the child as in satisfactory health condition, needing attention, or needing attention urgently. Of the 120 children in the study, 114 were found to have satisfactory health. No marked difference was found in general health according to the three IQ groups.

Dentists counted the permanent teeth of the children each year and also rated each child as in satisfactory dental health, needing attention, or urgently needing attention. At 113 months of age, sixty-four of the 120 children had satisfactory dental health, 43 were in need of attention, and 13 needed attention urgently. Dental health was related to IQ level with the incidence of satisfactory dental health 25% for the low IQ, 43% for the average IQ, and 83% for the high IQ. A similar pattern was found at 125 months of age.

Three clinical psychologists on the staff of the Wisconsin Diagnostic Center, Madison, Wisconsin, and eight school psychologists of the Madison and Milwaukee Public Schools assessed the personality of each child. After the assessment, the psychologists rated the child as in need of intensive therapy, in need of some therapy, or no therapy needed. The results were very similar for 1957-58 and 1958-59. Of 120 children in 1957-58, 90 needed no therapy or were apparently in good psychological health, 24 were in need of some therapy that was assumed could be handled by regular school personnel, and 6 were in need of intensive therapy. In 1958-59, 76 needed no therapy, 37 some therapy, and 7 intensive therapy. The psychological health of the children was generally good with no significant differences among the three IQ groups.

The occupations of the children's fathers was ascertained in 1956-57 and 1957-58. In 1958-59 the sample changed very little and the fathers' occupations remained nearly the same. In 1957-58, 29 fathers of the low IQ children were found in the unskilled, semi-skilled, and skilled occupational categories, whereas 34 of the high IQ children were found in the top two categories — professional, and managerial and official — with little overlap between these two IQ groups. The average IQ group clustered more toward the middle of the occupational categories with overlapping from semi-skilled through the professional occupations.

An attempt was made to determine whether the low IQ child's retardation was organic, hereditary, or combined. On the basis of case histories provided by the school, an estimate by the examining physician, and annual estimates by the examining psychologist, the investigators were unable to classify the children reliably. The estimated intelligence and actual educational achievements of the parents of the low IQ are considerably below national averages.

The times at which the various measures were secured have been indicated; now follows a brief description of each measure.

Acquisition, 5-minute retention, 6-week retention, and 12-week retention measures were secured in the addition task with the number of items correct used as the score. The same measures of acquisition and retention, with minor exceptions in the time intervals, were secured on each child in counting and subtracting. In the common problem-solving and differentiated problem-solving tasks, the acquisition and retention measures were secured at nearly identical time intervals as above with time in seconds as the measure of learning and relearning. The measures of acquisition and retention were secured on each child, individually, and purposeful variations in the teaching-learning sequence were incorporated to provide maximum opportunity to test the hypotheses dealing with acquisition and retention. A survey test was used with all tasks except common problem-solving in order to grade the tasks properly for each child.

Height was secured with a standing ruler attached to a beam scale and recorded in inches to the nearest 1/8 inch. Weight was secured simultaneously in pounds to the nearest 1/8 pound. Grip was measured in kilograms to the nearest 1/10, using a Smedley Hand Dynamometer, and the average of the two highest of the three readings was used. The number of permanent teeth was counted by a practicing dentist. Carpal age was ascertained through X-raying of the hand and wrist with the average of two independent readings used as carpal age.

WISC IQ was obtained according to standardized procedures with the total IQ score used in all subsequent analyses. Reading, arithmetic, and language achievements were secured through use of the California Achievement Battery, 1950, Form AA.

A personality assessment was made on each child, using the complete Rorschach Ink Blot Test, three selected Cards from the Thematic Apperception Test, one Draw-A-Figure, and a short clinical interview. From this information the child was rated on six variables by the examiner and a second psychologist. The average of the two ratings was used. Emotional adjustment, referring to the child's feeling and reactions to himself and others, was rated from 0-10 with 0 meaning very poor adjustment and 10 meaning excellent adjustment. Achievement in relation to capacity, implying achievement in relation to expectancy, was rated from 0-10 with 0 meaning far below expectancy and 10 meaning far above expectancy. Integration of self-concept, referring to the organization of the child's ideas about himself, was rated from 0-10 with 0 meaning very poorly organized and 10 meaning well organized. Expression of emotion, referring to how the child expressed his pleasant and unpleasant feelings, was rated from 0-10 with 0 meaning marked withholding of feelings and 10 meaning open and free expression of feelings. Pattern of behavior, referring to all forms of expression, was rated from 0-10 with 0 meaning muteness and withdrawing and 10 meaning high activity and aggressiveness. The child's estimate of his own abilities, referring to how the child estimated his own abilities related mainly to school work, was rated from 0-10 with 0 meaning greatly underestimating and 10 meaning greatly overestimating.

Handwriting speed was determined with a 5-minute test with the score the average number of letters written per minute. Sociometric scores were obtained by presenting the child a class list, having the child list his five best friends in order of preference, tabulating, and weighting the choices received by each child.

CONCLUSIONS

Hypothesis 1 states that speed of acquiring arithmetic learning is inversely

3

related to retention among groups of children of low, average, and high intelligence. The hypothesis, therefore, implies a higher ratio score between learning and relearning times for the low IQ children than for the high IQ children. Differences among the means of ratio scores by a test of the analysis of variance should be significant at the .01 level to support the hypothesis. Based upon the ratio scores from the common problem-solving task between time to learn and time to relearn at 5-minute, 6-week, and 12-week intervals, the hypothesis was rejected. Speed of acquiring arithmetic learning is not inversely related to retention among groups of children of low, average, and high intelligence; the ratio between learning and relearning time is the same among children of low, average, and high intelligence.

Though the ratio between rate of acquiring and rate of forgetting is the same among children of low, average, and high intelligence, the rate of acquiring overall arithmetic learnings is much lower for the low IQ than for the other two groups. The low IQ children, with considerable help, acquired a solution to the common problem involving the sharing of an amount of money with a specified number of friends in 631 seconds, the average IQ in 235 seconds, and the high IQ in 237 seconds. On the standardized tests in arithmetic, the low IQ children were 26 months below the average IQ and 40 months below the high IQ at 113 months of age; and 31 months below the average IQ and 41 months below the high IQ at 125 months of age. As shown in the survey results for addition, subtraction, and differentiated problem solving, the highest low IQ child was considerably below the lowest average IQ child.

Hypothesis 2 states that retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level. The acquisition-retention tasks in counting, addition, subtraction, and differentiated problem-solving were used to test this hypothesis using analysis of covariance. Whether using the relationship between acquisition and 5-minute retention or acquisition and a subsequent measure of retention such as at the end of 6 or 12 weeks, the hypothesis was upheld. Similarly, the hypothesis was upheld whether using number of items correct as the score or whether using time in seconds. Furthermore, the applied measure of retention, transfer, yielded the same results as did the direct measure. Under purposely designed variations in the teaching-learning procedure preceding the securing of the acquisition score and with the subjects at four different mean ages, retention of arithmetic learning is the same among children of low, average, and high intelligence when the original learning task is graded to the learner's achievement level.

Hypothesis 3 states that uneven physical development within the child accompanies low achievement in arithmetic and in reading. This was rejected with children at mean ages at 101, 113, and 125 months of age respectively. Though rejected, all the correlations were in the negative or hypothesized direction.

Hypothesis 4 states that a low level of physical development within the child accompanies low achievement in arithmetic and reading. This hypothesis was also tested with the children at mean ages of 101, 113, and 125 months respectively. The hypothesis was rejected for both sexes for the three years except in 1956 when it was upheld for boys.

Hypothesis 5 states that the within-child variability in grip, IQ, reading, arithmetic and language achievement is the same among children of low, average, and hich intelligence. This hypothesis was tested with the children at mean ages of 101, 113, and 125 months, and was rejected each time. The within-child variability in grip, IQ, reading, arithmetic, and language achievement is not the same among children of low, average, and high intelligence. The low and high IQ children showed the same within-child variability, however, the average IQ children showed less within-child variability then the other two groups.

Truncated Hypothesis 5 states that the within-child variability in reading, arithmetic and langauge is the same among children of low, average, and high intelligence. This hypothesis was also tested with children at 101, 113, and 125 months of age and was upheld each time.

Conclusions from the analysis of the intercorrelations of physical, mental, achievement, and personality measures state the extent to which likenesses and differences in main patterns of correlations for the 60 boys and 60 girls occurred during the two years.

At 113 and 125 months of age, height, weight, grip, and carpal age were positively and significantly correlated for both sexes. Dentition correlated inconsistently and generally not significantly with the other four physical measures. Strength of grip correlated positively and generally significantly with IQ, reading achievement, arithmetic achievement, language achievement, and handwriting. The correlations between each physical measure, except grip, and each other measure are generally not significant.

IQ, reading achievement, arithmetic achievement, language achievement, and handwriting correlated high, significantly and positively. The IQ and achievement measures did not correlate consistently with other measures except with strength of grip as noted above, and with two personality ratings — achievement in relation to capacity and integration of self-concept. These correlations were higher for girls than for boys.

Chronological age showed no significant correlation with the other measures. In setting up the study the researchers intended to secure a sufficiently narrow range in chronological age, 15 months, in order to secure nonsignificant correlations with the other measures.

Two main patterns of significant and positive correlations emerge related to the personality ratings. Emotional adjustment, achievement in relation to capacity and integration of self-concept correlated positively and generally significantly for both sexes. Expression of emotion, behavior pattern, and the child's estimate of his own abilities also showed positive and usually statistically significant correlations for both sexes at 113 and 125 months of age. Two personality ratings — achievement in relation to capacity and integration of self-concept —

correlated positively and generally significantly with IQ, reading achievement, arithmetic achievement, language achievement and handwriting with higher correlations for girls than for boys.

Handwriting correlated positively, generally high and significantly with IQ, reading achievement, language achievement, strength of grip, achievement in relation to capacity, and integration of self-concept. Equally important, handwriting was found not to correlate significantly with four physical measures: height, weight, number of permanent teeth and carpal age.

The sociometric scores for the average and high IQ children did not correlate significantly with any other measure except two personality ratings -- achievement in relation to capacity and integration of self-concept. The low IQ children were not included in the total group of 60 boys and 60 girls when computing correlations between sociometric scores and other variables because of the system of weighting the sociometric test scores.

Differences among mean scores for the three IQ groups and for boys and girls were ascertained for 14 measures common to the last two years of the study and also for two measures secured only with the children at a mean age of 125 months. The results of this analysis are now given, first for differences and likenesses among the IQ groups and then for the sex groups.

At both 113 and 125 months of age there was no significant difference among the three IQ groups in six measures -- weight, number of permanent teeth, carpal age, emotional adjustment, emotional expression, and behavior pattern. At 113 months of age the low IQ children were significantly lower than the average and the average were significantly lower than the high IQ children in four measures -- strength of grip, reading achievement, arithmetic achievement, and language achievement. The same conclusion holds at 125 months of age except that in strength of grip there was no significant difference between the average and high IQ children.

At 113 months of age there was no difference in achievement in relation to capacity; but at 125 months of age the low IQ children were lower than the average and the average IQ children were lower than the high IQ. At 113 months of age there was no difference in integration of self-concept; but at 125 months of age the low IQ children were lower than the average and the high IQ children who were the same. At 113 months of age there was no difference in the three groups in the child's estimate of his own abilities; but at 125 months of age the average IQ children were significantly lower than the high or low IQ who were the same.

At 125 months of age there was no difference between the average and high IQ groups in sociometric scores. Only the average and high IQ groups and boys and girls were compared. At 125 months of age the low IQ children had lower handwriting speed than did the average and high IQ who had equal speed.

At 113 months of age significant differences between mean scores of the 60 boys and 60 girls were found in four measures — girls had lower grip scores, more permanent teeth, higher carpal age, and achieved higher in relation to capacity than the boys. At 125 months of age the only significant differences were in two measures: girls had lower strength of grip and achieved higher in relation to capacity than boys. Thus, the boys caught up or nearly so to the girls in number of permanent teeth and carpal age.

IMPLICATIONS

[The evidence strongly suggests that there is no difference in retention of 57 arithmetic learnings among children of low, average, and high intelligence when the learning task is graded to each child's current achievement level and retention is measured in units of practical arithmetic exercises or in time to learn or relearn to solve a novel arithmetic problem.] The researchers believe that the same results would be found in other areas of cognitive learning, such as vocabulary, reading, science concepts, social studies concepts, and the like. The most important implication of the entire study is that classroom teachers of the mentally retarded children as well as teachers of other children should early in the school year find out the present achievement levels of the individual children in the class, select learnings at next higher levels of difficulty, and offer individualized or small-group instruction in order to promote efficient acquisition and subsequent retention. The low IQ children, more slowly than the average and high IQ children, can acquire material that is graded to their level of difficulty and retain what is acquired as well as do the children of average and high intelligence. The researchers experienced only minor motivational problems in teaching the children of low, average, or high intelligence. Apparently, when an individual child is presented a task to learn which he has some confidence he can acquire, no further motivational techniques are needed other than perhaps partial reinforcement of correct responses and approval of the teacher.

The research showed that to some extent the average IQ and to a great extent the high IQ children efficiently acquired and retained arithmetic learnings considerably beyond those included in their present curriculum. Based on extensive study of the results of achievement testing in many schools of Wisconsin, the principal investigator believes that the curriculum in arithmetic is directed primarily toward children of average intelligence. The researchers believe that were teachers able to reliably identify what the child knows and start each child's instruction at that level, efficiency in acquiring arithmetic could be increased over the present by at least one grade level and possibly two for high IQ children by the end of the fifth grade. Some low IQ children in the present study also were found to be achieving at a much higher level than would normally be expected of low IQ children. Somewhere between 110 and 120 months of age many of the low IQ children seem to be able to start acquiring arithmetic much more efficiently than at earlier ages.

Level of physical development in the composite of height, weight, strength of grip, and carpal age is quite useless in attempting to understand a child's pattern of failures and successes in most school activities. Uneven physical development in these measures warrants further research. It is possible that some sort of chemical imbalance within the child or a pattern of rhythmic rate of growth leads to differences within the child in these four physical measures which may in turn be reflected in lower school achievements. The variability within the child in reading, arithmetic, and language was found to be the same for low, average, and high IQ children. This suggests that a teacher of low IQ children would need to individualize instruction to take into account differences within the child in his levels of reading, arithmetic, and language achievement to the same extent as would a teacher of a homogeneous class of high or a teacher of a homogeneous class of average IQ children.

Related to the differences among IQ groups and also to the correlations, the researchers recommend that school systems would profit from securing certain measures used in this study on all children, including the low IQ, in this order: IQ or MA with an individual intelligence test; reading achievement, arithmetic achievement, and language achievement with standardized tests, preferably diagnostic; individualized arithmetic tests with the low IQ children as illustrated in the survey test of addition, subtraction, and counting used in this study; handwriting speed and quality with a teacher-made test; peer acceptance with a teacher-administered sociometric test; strength of grip with a hand dynamometer; and an experienced school or clinical psychologist's ratings of integration of self-concept, emotional adjustment, and general need for therapy using projective techniques. Although perhaps of some value for research and perhaps medical purposes, teachers will profit little or not at all from securing measures of height and weight which are easy to secure, carpal age which is difficult and expensive to secure, and number of permanent teeth which is somewhat expensive and not easy to secure. The researchers further recommend that the IQ and personality assessments be made at least every two years and that the other measures recommended as worthwile above, be secured annually.

The design of this study and its execution clearly suggest that persons interested in human learning and in human behavior can design studies which provide information that is more useful than most of that currently available from laboratory studies. Of particular significance is the fact that human subjects at the grade level at which one wishes to generalize can be used successfully, that socially useful rather than nonsense material can serve as the material for measuring acquisition and retention, and that learning tasks can be graded to each child's level of achievement. With improvements in the design as researchers can undoubtedly make, it is entirely possible that many of the current hunches and guesses about arithmetic learning and retention and other characteristics of children of low, average, and high intelligence will give way to factual evidence.

BIBLIOGRAPHY

Ames, R., (1957), "Physical Maturing Among Boys as Related to Adult Social Behavior," *California Journal of Educational Research*, 8:73.

Archer, E. James, (1953), "Retention of Serial Nonsense Syllables as a Function of Rest-Interval Responding Rate and Meaningfulness," *Journal of Experimental Psychology*, 45:245-252.

Auble, D., and Mech, E. V., (1953), "Partial Verbal Reinforcement Related to Distributed Practice in a Classroom Situation," *Journal of Psychology*, 36:165-186.

Ausubel, D. P., (1953), "The Nature of Educational Research," *Educational Theory*, 3:314-320.

Ausubel, D. P., Robbins, L. C., and Blake, E., Jr., (1957), "Retroactive Inhibition and Facilitation in the Learning of School Materials," *Journal of Educational Psychology*, 48:334-343.

Bayley, N., (1956), "Individual Patterns of Development," *Child Development*, 27:45-74.

Bayley, N., (1955), "On the Growth of Intelligence," *American Psychologist*, 10:805-818.

Beilin, H., (1957), "The Prediction of Adjustment Over a Four Year Interval," *Journal of Clinical Psychology*, 13:270-274.

Blommers, P., Knief, L. M., and Stroud, J. B., (1955), "The Organismic Age Concept," *Journal of Educational Psychology*, 46:142-150.

Bonney, M. E., (1943), "The Constancy of Sociometric Scores and Their Relationship to Teacher Judgments of Social Success and to Personality of Self-Ratings," *Sociometry*, 6:409-424.

Bunch, M. E., (1941), "The Measurement of Retention by the Relearning Method," *Psychological Review*, 48:450-456.

California Test Bureau, (1950), *Manual for the California Achievement Tests*, Form AA. Los Angeles, California Test Bureau.

Capobianco, Rudolph J., (1954), "A Comparative Study of Endogenous and Exogenous Mentally Handicapped Boys on Arithmetic Achievement," *Dissertation Abstracts*, 14:794-795. Abstract of Ed.D. Thesis, 1954, University of Illinois.

Cattell, Psyche, (1929), "Dentition as a Measure of Maturity," *Harvard Monographs in Education*, 9.

Check, John F., (1959), "A Study of Retention of Arithmetic Learning With Children of Low, Average, and High Intelligence at 127 Months of Age" (unpublished Ph.D. Dissertation), University of Wisconsin.

Clancy, N., and Smitter, F., (1953), "A Study of Emotionally Disturbed Children in Santa Barbara County Schools," *California Journal of Educational Research*, 4:209-218.

Dietze, Alfred G., (1931), "The Relation of Several Factors to Factual Memory," *Journal of Applied Psychology*, 15:563-574.

Duncan, C. P., (1958), "Transfer After Training With Single Versus Multiple Tasks," *Journal of Experimental Psychology*, 55:63-72.

Ebbinghaus, H., (1885), *Memory*. New York: Teachers College, Columbia University.

Edwards, A. L., (1950), *Experimental Design in Psychological Research*. New York: Rinehart and Company.

Enos, Frank, (1958), "A Study of the Relationships Between Physical Status, Emotional Adjustment, and Friendship Choices of Fourth-Grade Children," (unpublished Ph.D. Dissertation), University of Wisconsin.

Feldhusen, John F., (1958), "A Study of Efficiency of Learning and Retention in Arithmetic Among Children of Low, Average, and High Intelligence at a Mean Age of 112 Months," (unpublished Ph.D. Dissertation), University of Wisconsin.

Feldhusen, John F., and Klausmeier, Herbert J., (1959), "Achievement in Counting and Addition," *Elementary School Journal*, 388-393.

Francis, R. J., and Rarick, G. L., (1959), "Motor Characteristics of the Mentally Retarded," *American Journal of Mental Deficiency*, 63:792-811.

Gallagher, James J., (1957), "A Comparison of Brain-Injured and Non-Brain-Injured Mentally Retarded Children on Several Psychological Variables," *Society for Research in Child Development*, 22:1-79.

Gallagher, J. J., (1958a), "Peer Acceptance of Highly Gifted Children in Elementary School," *Elementary School Journal*, 465-470.

Gallagher, J. J., (1958b), "Social Status of Children Related to Intelligence, Propinquity, and Social Perception," *The Elementary School Journal*, 225-231.

Gates, A. I., (1924), "The Nature and Educational Significance of Physical Status and of Mental, Physiological, Social, and Emotional Maturity," *Journal of Educational Psychology*, 15:329-358.

Gates, A. I., (1941), "The Role of Personality Maladjustment in Reading Disability," *Journal of Genetic Psychology*, 59:77.

Gillette, Annette L., (1936), "Learning and Retention," *Archives of Psychology*, No. 198.

Gilliland, A. R., (1948), "The Rate of Forgetting," *Journal of Educational Psychology*, 39:19-26.

Gleason, Gerald T., (1956), "A Study of the Relationship Between Variability in Physical Growth and Academic Achievement Among Third-and Fifth-Grade Children," Ph.D. Thesis, University of Wisconsin.

Gleason, G. T., and Klausmeier, H. J., (1958), "The Relationship Between Variability in Physical Growth and Academic Achievement Among Third-and Fifth-Grade Children," *Journal of Educational Research*, 51:521-527.

Grant, Marion E., (1932), "Some Theories and Experiments in the Field of Memory," *Journal of Educational Psychology*, 23:511-527.

Greulich, W. W., and Pyle, S. I., (1950), *Radiographic Development of the Hand and Wrist* (Based on the Brush Foundation Study of Human Development by T. Wingate Todd). Stanford: Stanford University Press.

Gronlund, N. E., (1955), "The Relative Stability of Classroom Social Status With Unweighted and Weighted Sociometric Choices," *Journal of Educational Psychology*, 46:345-354.

Hall, J. F., (1955), "Retroactive Inhibition in Meaningful Material," *Journal of Educational Psychology*, 46:47-52.

Harlow, H. F., (1949), "The Formation of Learning Sets," *Psychological Review*, 56:51-65.

Harris, C. W., and Bereiter, C. E., (1959), "Individual Differences," *Annual Review of Psychology*, 10:89-108.

Hertz, M. R., (1951a), "Current Problems in Rorschach Theory and Technique," *Journal of Projective Techniques*, 15:307-338.

Hertz, M. R., (1951b), *Frequency Tables to be Used in Scoring Responses to the Rorschach Ink-Blot Test.* Cleveland: Western Reserve University, 3rd. ed.

Johnson, G., (1950), "A Study of the Social Position of Mentally Handicapped Children in the Regular Grades," *American Journal of Mental Deficiency*, 50:60-89.

Jones, M. C., and Bayley, N., (1950), "Physical Maturing Among Boys as Related to Behavior," *Journal of Educational Psychology*, 41:129-148.

Katona, George, (1940), *Organizing and Memorizing*. New York: Columbia Universit Press.

Klausmeier, H. J., (1958), "Physical, Behavioral, and Other Characteristics of High-and Lower-Achieving Children in Favored Environments," *Journal of Educational Research*, 51:573-582.

Klausmeier, H. J., Beeman, A., and Lehmann, I. J., (1958), "Comparison of Organismic Age and Regression Equations in Predicting Achievements in Elementary School," *Journal of Educational Psychology*, 49:182-186.

Klausmeier, H. J., and Check, J., (1959), "Relationships Among Physical, Mental, Achievement, and Personality Measures in Children of Low, Average, and High Intelligence at 113 Months of Age," *American Journal of Mental Deficiency*, 63:1059-1068.

Klausmeier, H. J., Lehmann, I. J., and Beeman, A., (1959), "Relationships Among Physical, Mental, and Achievement Measures in Children of Low, Average, and High Intelligence," American Journal of Mental Deficiency, 63:647-656.

Koffka, Kurt, (1935), Principles of Gestalt Psychology. New York: Harcourt-Brace.

Krogman, W. M., (1956), "The Physical Growth of Children: an Appraisal of Studies," Monograph of the Society for Research in Child Development, 20:1-91.

Lantz, B., and Tobias, M., (1956), "Learning, Personality, and Physiological Interactions," California Journal of Educational Research, 7:153-158.

Leavitt, H. J., (1945), "The Relation of Speed of Learning to the Amount Retained and to Reminiscence," Journal of Experimental Psychology, 35:134-140.

Luh, C. W., (1922), "The Conditions of Retention," Psychological Monographs, Vol. 31, No. 3.

McNemar, Q., (1949), Psychological Statistics. New York: John Wiley and Sons, Inc.

Mohom, E., (1943), "Affectivity and Growth in Children," Child Development, 14:91-115.

Olson, W. C., (1949), Child Development. Boston: D. C. Heath and Co.

Olson, W. C., and Hughes, B. O., (1950), Manual for the Description of Growth in Age Units. Ann Arbor: University of Michigan Press.

Orata, Pedro T., (1941), "Recent Research Studies on Transfer of Training With Implications for the Curriculum, Guidance, and Personnel Work," Journal of Educational Research, 35:81-101.

Pepinsky, P. N., (1949), "The Meaning of 'Validity' and 'Reliability' as Applied to Sociometric Tests," Educational and Psychological Measurement, 9:39-49.

Postman, L., Jenkins, W., and Postman, D., (1948), "An Experimental Comparison of Active Recall and Recognition," The American Journal of Psychology, 61:511-519.

Research Committee of the California Association of School Psychologists and Psychometrists, (1954), "Emotionally Disturbed Children in California," California Journal of Educational Research, 5:116-120.

Rustebakke, A. R., Kreider, R., and Haner, C. F., (1954), "A Comparison of Absolute Overlearning on the Retention of Fast and Slow Learners," Proceedings of the Iowa Academy of Science, 61:413-416.

Smith, L. M., (1958), "The Concurrent Validity of Six Personality and Adjustment Tests for Children," Psychological Monographs, 72: No. 457 (whole) 30 pp.

Snedecor, George W., (1955), *Statistical Methods*. Ames: Iowa State College Press, 251-253.

Sontag, L. W., Baker, C. T., and Nelson, V. L., (1958), "Mental Growth and Personality Development: a Longitudinal Study," *Monograph of the Society for Research in Child Development*, 23:1-143.

Spitzer, H. F., (1939), "Studies in Retention," *Journal of Educational Psychology*, 30:641-656.

Sterrett, M. D., and Davis, R. A., (1954), "The Permanence of School Learning: A Review of Studies," *Educational Administration and Supervision*, 40:449-460.

Stevenson, H. W., and Zigler, E. F., (1957), "Discrimination Learning and Rigidity in Normal and Feebleminded Individuals," *Journal of Personality*, 25:699-711.

Tyler, F. T., (1953), "Concepts of Organismic Growth: A Critique," *Journal of Educational Psychology*, 44:321-342.

Underwood, B. J., (1954), "Speed of Learning and Amount Retained: A Consideration of Methodology," *Psychological Bulletin*, 51:276-282.

United States Employment Service, (1949), *Dictionary of Occupational Titles*.

Walker, H. M., and Lev, J., (1953), *Statistical Inference*. New York: Henry Holt and Company.

Waters, R. H., (1941), "The Interpretation of Ebbinghaus's Retention Values," *American Journal of Psychology*, 52:283-286.

Wechsler, D., (1949), *Wechsler Intelligence Scale for Children, Manual*. New York: The Psychological Corporation.

Worcester, D. A., (1957), "Learning Ability and Retention After Long Periods," *Journal of Educational Psychology*, 48:505-509.

Zimny, G. H., (1949), "The Speed of Learning in Relation to the Amount Retained After Different Time Intervals Following Original Learning," *American Psychologist*, 4:219-220.

APPENDIX A
MEDICAL EXAMINATION FORM

Name of child ____________________ Birthdate ____________________

Address ____________________ Parent's name ____________ Phone ____

Date of examination ____________________ By ____________________

I. Height __________ Temperature ________ Systolic blood pressure __________

Weight __________ Pulse rate ________ Diastolic pressure __________

Respiration ________

Bony structure and posture ________________________________

II. Skin: Condition ____________________ Color ____________________

Pubic hair ____________________ Axillary hair ____________________

III. Eyes, Ears, Nose, Throat:

Eyes: Acuity Right ________ Left ________

Ears: Hearing Right ________ Left ________

Drums Right ________ Left ________

Nose:

Mouth:

Tonsils:

Speech:

IV. Chest:

Respiratory condition

Lung condition

Heart condition

Heart rate - resting

2" after exercise

V. Abdomen

VI. Genitalia

Anal region

VII. Deep Tendon Reflexes:

	Right	Left		Right	Left
biceps	____	____	knee	____	____
triceps	____	____	ankle	____	____

Pathological Reflexes:

Babinski____________ **Romberg**____________

VIII. Congenital anomalies

IX. Summary of Examination:

Check one: **Needs attention urgently**____________

Needs attention____________

Is in good health____________

Is in excellent health____________

Comments to clarify rating:

For low IQ children only (check one)

Etiology is probably hereditary ( )

Etiology is probably organic ( )

Etiology is probably a combination of organic and hereditary ( )

Etiology is unclassified ( )

APPENDIX D

DENTITION INFORMATION FORM

Name ______________________________ Birthdate ____________________

Date of Examination ____________________ Dentist ______________________

PERMANENT TEETH

Right														Left		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Uppe
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	Lowe

Key to filling in tooth numbers--only permanent teeth to be noted--with entry abov permanent tooth number as follows:

A -- absent but was present at one time
H -- the crown between one-third and two-thirds through
P -- from two-thirds of the way to full occlusion with as much recession of the gums as takes place under normal conditions
HA -- permanent tooth would be present but is not because of hereditary anomol

*where child has additional permanent tooth for any reason, locate in above chart between the normal tooth numbers.

Summary of Examination

Gum condition: (check one condition)

Needs attention urgently ________________________
(Dentist recommends treatment as soon as possible)

Needs attention ________________________
(Dentist recommends attention within a 6-months period)

Satisfactory condition ________________________

Teeth condition: (check one condition)

Needs attention urgently ________________________
(One or more permanent teeth with readily observed cavities; or, one or more temporary teeth need extraction; or, serious malformation which involves or will involve permanent teeth; dentist recommends treatment as soon as possible.)

Needs attention ________________________
(One or more temporary teeth which will not be replaced for some time have cavities; if this child were dentist' patient, he would recommend care at least within the next six months.)

Satisfactory condition ________________________

APPENDIX C

FORMS USED FOR PERSONALITY ASSESSMENT

Name____________________ Rorschach________ TAT_____ Fig. Dr.____

Date of evaluation____________________ Data rated: 1)____________________
2)____________________
3)____________________

Tested by____________________

Etiology: Primary____________ Secondary________ Unknown________

A. EMOTIONAL ADJUSTMENT	Excellent	Poor
B. ACHIEVEMENT	Above expectancy	Under expectancy
C. INTEGRATION OF SELF-CONCEPT	Well-organized	Poorly-organized
D. EXPRESSION OF EMOTION	Extrovert	Introvert
E. PATTERN OF BEHAVIOR	Aggressive	Withdrawn
F. CHILD'S ESTIMATE OF OWN ABILITIES	Over	Under
G. ACCEPTANCE OF SELF	High Degree	Low degree
H. SENSITIVITY TO OTHERS (EMPATHY)	Much	Little

Comments:

DRAW A PERSON

Name_______________________________ M________

Date_______________________________ F________

1. How old is he (or she)?

2. How smart is he (or she)?

3. How well does he (or she) do in school?

4. What does he (or she) want to be when he (or she) grows up?

APPENDIX D

INSTRUCTIONS AND RELATED FORMS FOR THE COUNTING TASK

I. Introduction of child to situation

Introduce pupil to other examiner and then say, "We're going to do some arit metic and other things today. With which hand do you write? All right, here's a pencil and paper you can use later. Let's put your other hand here and place thi gadget on it. So, while you're here this is going to be on your hand. Does it feel all right?" (If pupil asks about the electrodes, say, "This is used to find out how your hand acts while you are working and playing.") "Now let's begin."

II. Survey procedure

1. Estimate in terms of the pupil's IQ and school level where to start a series. Start at one level below the pupil's estimated level. The following are the probable levels of task difficulty:

a) counting by 1's
b) counting by 2's
c) counting by 10's, by 5's (Grade 2)
d) counting by 3's, 4's, 6's (Grade 3)
e) counting by 7's, 8's, 9's (Grade 4)
f) counting by 11's, 12's, 13's.

2. Say, "Let's see how well you can count by

a) 1's -- can you do it?" (stop at 29)
b) 2's -- can you do it?" (stop at 20)
c) 10's-- can you do it?" (stop at 100)
d) 5's -- can you do it?" (stop at 50)
e) 3's -- can you do it?" (stop at 30)
f) 4's -- can you do it?" (stop at 40)
g) 6's -- can you do it?" (stop at 60)
h) 7's -- can you do it?" (stop at 70)
i) 8's -- can you do it?" (stop at 80)
j) 9's -- can you do it?" (stop at 90)
k) 11's-- can you do it?" (stop at 110)
l) 12's-- can you do it?" (stop at 120)
m) 13's-- can you do it?" (stop at 130)

3. Cease a series when two errors are made in succession. A correction made by the pupil himself is not considered an error.

4. No coaching, no mention of "right" or "wrong," no use of counting aids, e.g., pennies, pencil and paper, is permitted in this survey.

5. Determine the level where the teaching will begin. The new task will start from the first error made and will include 11 consecutive steps in the particular series where the errors occur. Thus, for example, in the series of 7's, if pupil fails at 21 and 28 the teaching task will include 11 counting steps by 7's from 21 to 91.

III. Teaching procedure

1. Teaching is limited to 20 minutes. The task is considered learned when the child can repeat the 11 new numbers correctly and without assistance in 15-60 seconds. Pennies may be used in illustrations. Pupil may use pencil and paper if he wishes.

2. Present the new task (11 correct responses) once to student, saying, "Listen how I count by (7's). Now you try it." (If pupil reproduces task in 60 seconds or less with two or less errors, go to the next higher level task and repeat procedure for presenting new task.)

3. Examiner reinforces correct responses by saying, "That's right," "Right," or "Correct" to about 50% of the right answers given, corrects errors made by pupil if pupil does not do so, offers use of paper and pencil when pupil cannot get next response, and gives correct response when pupil cannot do so after 30-45 seconds.

4. Examiner records number of minutes it took pupil to learn the new task. This estimate is made during the teaching and involves no specific question. Rather, examiner notes the time at which pupil has learned the sequence. If pupil learns the task before the 20 minutes are up, examiner may use overlearning devices such as

a) Demonstrate that the progression involves adding

$$\begin{array}{rrrr} 7 & 14 & 21 & 28 \\ +7 & +7 & +7 & +7 \\ \hline 14 & 21 & 28 & 35 \end{array}$$

b) Ask what comes after (or before) 21.
c) Introduce simple multipication facts, e.g., "Counting three 7's is the same as 'three times 7.'"
d) Ask, "Three (or four) 7's are how much?"

5. At the end of 19 minutes, examiner says, "Now let us see how well you learned to count by (7's). Can you count once more by (7's from 21 to 91)?" Examiner records how many of the 11 new numbers were learned correctly.

IV. Reading procedure

Examiner gives pupil some books and says, "You've done well today. Here are some books to look at and read for a while. Which one do you like most?" (5 min.)

V. Retention procedure

1. After 5 minutes, say, "Let's see how well you remember the numbers you just learned. Can you count once more by (7's from 21 to 91)?"

2. If pupil falters, examiners may give only the first one of the 11 numbers, but may give an entire previous level sequence, e.g., 6's.

APPENDIX E

INSTRUCTIONS AND RELATED FORMS FOR THE COMMON PROBLEM-SOLVING TASK

I. Introduction of child to situation

Introduce pupil to other examiner and then say, "We're going to solve a problem and do some other things today. With which hand do you write? Let's put your other hand here and place this gadget on it. So, while you're here this is going to be on your hand. Does it feel all right?" (If student asks about the electrodes, say, "This is used to find out how your hand acts while you are workin and playing.") "Now let's begin."

II. Testing and/or Teaching procedure

1. Testing is limited to 20 minutes. The task is considered learned when the child has divided the pennies as directed and given the correct answer to the problem. If the child completes the task in less than 20 minutes, record time of completion.

2. Present the task, saying, "Here is a pile of pennies. I will not tell you how many. But suppose you wanted to give the same number of pennies to (7,8, 7,9,8) of your friends, keeping none for yourself. (For successive children use 56, 56, 63, 63, and 64 pennies. Also make certain that the five problems are distributed equally within each IQ level.) "Divide the pile of pennies so that there are the same number of pennies for each of your (7,8,7,9,8) friends. When you finish, tell me how many pennies each of your friends would get. Do you understand what you are to do?"

Answer questions about problem here but do not answer questions about solution. Do not allow S to touch pennies until questions have been answered. If there are no questions, S may begin immediately. Time is started with the beginning of instructions "Here is a pile. . ." Time ends when S has divided the pennies and given the right number per friend. (When the child has divided the pennies into piles, E asks S for the number per friend if S does not offer it.)

3. If questions have been answered and S is still unable to make a correct beginning, E may repeat any or all of the directions as often as necessary during the first 4 minutes. E may also encourage S to persist in solving the task if S's attention wanes.

4. If S has made no correct beginning at the end of 4 minutes, E suggests that S arrange (7,8,7,9,8) pennies in a row. E says, "Let's begin by placing (7,8,7,9,8) pennies in a row so that the pennies are about this far apart" (1 inch. Here E puts only 3 of the pennies in a row to indicate the distance.

5. If S has made no additional progress at the end of 8 minutes, E proceeds as follows: (A) If S has not placed the first pennies in a row, E counts (7,8,7,9, 8) pennies and helps S arrange them in a row; (B) If S has only succeeded in establishing the row of pennies, E says, "Let's put the other pennies on one of these (point to separate pennies in a row) so that we will have the same number of pennies in each pile when they have all been divided."

6. If S has made no additional progress at the end of 12 minutes, E proceeds as follows: (A) Give directions B in No. 5 above if S received only directions A at the end of 8 minutes; (B) Take the pennies one at a time from the supply and place them on the separate piles in order to build each pile to five pennies per pile.

7. If S still makes no progress in completing the division, E goes through entire division except for last penny per pile and counting of pennies per pile. (Wherever help stops, child should correctly give number of pennies per child.)

8. If S has not completed the task at the end of 15 minutes, E repeats the problem and presents the solution, stating what he does. Here E asks S if he understands. Then E puts all pennies into larger pile and again states problem. E may use all the time to the end of 20 minutes here and give further help so that the child completes the task correctly once--even if by rote.

9. If S completes the task in less than 20 minutes, record time and immediately go to III.

10. E reinforces no correct partial response if S needs no help. E must check accuracy of final division and correctness of number. If S needs help E says "That's right," "Right," or "Correct" to any partial response.

11. The task is to be changed with each child, using the 56--7, 8 division, the 63--7, 9 division, and the 64--8 division. If deemed necessary, 72 pennies with an 8,9 division may also be used.

Total	Task
56 pennies	Divide among 7 friends.
	Divide among 8 friends.
63 pennies	Divide among 7 friends.
	Divide among 9 friends.
64 pennies	Divide among 8 friends.

Note results obtained within a school. If time of solving drops markedly, go to 72 pennies with an 8,9 arrangement, next 70 pennies with a 7,10 arrangement.

III. Reading procedure

E gives S some books and says, "You've done well today. Here are some books to look at and read for a while. Which one do you like most?" (5 minutes) (May chat and converse with child about book or story, not about the task.)

IV. Retention procedure

After 5 minutes, say, "Here is the same problem you did before. Let's see how quickly you can do it now." Here E repeats the initial directions; time starts after problem is stated. Allow up to 3 minutes without help, up to 7 minutes with help.

COMMON PROBLEM-SOLVING TASK I

Data Sheet

Name ____________________ Examiner ________________ Date of test ______

ID Number __________

Amount of time required for first acquisition __________

Comment to indicate extent of help given. Check one:

No help ____________________

Level 3 help ____________________
(answer questions and encourage)

Level 4 help ____________________
(placing 3 pennies)

Level 5 help A ______ B ______

Level 6 help A ______ B ______

Level 7 help ______________

Level 8 help ______________

Remarks:

Amount of time required after 5 minutes reading ______________

Comment to indicate extent of help given. Check one:

No help ______________

Level 3 help ______________

Level 4 help ______________

Level 5 help A ______ B ______

Level 6 help A ______ B ______

Level 7 help ______________

Level 8 help ______________

Remarks:

Date of 6-weeks retest ______________ Examiner ____________________

Amount of time required for retest acquisition ______________

Comment to indicate extent of help given. Check one:

No help ______________

Level 3 help ______________

Level 4 help ______________

Level 5 help A ______ B ______

Level 6 help A ______ B ______

Level 7 help ______________

Level 8 help ______________

Remarks:

APPENDIX F

INSTRUCTIONS AND RELATED FORMS FOR THE ADDITION TASK

I. Introduction of child to situation

Introduce child to other examiner and then say, "We're going to do some arithmetic and other things today. With which hand do you write? All right, here' a pencil and paper you can use later. Let's put your other hand here and place this gadget on it. So, while you are here this is going to be on your hand. Does it feel all right?" If S asks about the electrodes, say, "This is used to find out how your hand acts while you are working and playing." "Now let's begin."

1a. Six-week Retention Procedure for the penny problem
Use the original directions for this task and be sure to use the same penny combination as in the original situation. No warmup will be used. A maximum of 7 minutes will be allowed, 3 minutes without help. Indicate level of help given.

II. Survey procedure

1. Ask if S can read or recognize numbers. Follow A if S (low IQ child) cannot read numbers or addition forms, B for any low IQ and other children who can read symbols and numbers.

Procedure A. "I have some questions here in arithmetic. Let's see how many you can answer." (E carries out survey levels 1, 2, 3, using symbols only but changing "+" to "and" and reading the exercise for the child as necessary and writing in correct answer.

Procedure B. "Here are some problems in addition. Start here (level 6), do these first two." If no error is made go to level 7. Repeat procedure through consecutive levels until two errors are made among three items of a level. However, when the first two are worked correctly, proceed to the next level without working the third item.

2. Cease a series when two errors are made in a series of three. A correction made by S himself is not considered an error.

3. No coaching, but encouraging to try, no mention of right or wrong, no use of counting aids is permitted. Pencil and paper are to be used by everyone.

4. Determine the level where the teaching will begin. The new task will include 10 new problems in the particular series where 2 errors occurred.

III. Teaching procedure

1. Teaching is limited to 17 minutes and 5 minutes is allowed to present the first acquisition test if the task has not or has just been learned for a total of 22 minutes. The task is considered learned when S has done the 10 new exercises correctly with assistance. (The assistance may include giving the answer to S or working the exercise for him.). If S completes the learning sequence in less than 17 minutes, record time of completion, give first acquisition test, and proceed to the five-minute reading procedure.

2. Present the new addition task saying, "You were able to add these numbers correctly (pointing to one survey item in new level or 2 or 3 items in previous level correctly performed). Now here are some more addition problems. Let's look at the first one and do it together." (general principle: teach the new exercise and underlying process with as much meaning as possible, using dots (low IQ) and pencil-and-paper representations as necessary. Do not use over three minutes in teaching the process and first exercise. Allow an additional ½ minute (for a total of 3½ minutes) to work problem for S if S does not learn how to do it within the 3 minutes. Do not use over one minute to teach each succeeding exercise nor allow over an additional ½ minute to show S how to work the problem if he does not succeed in working it correctly within the one-minute time limit. Thus, the maximum time for each item 2 through ten is 1½ minutes. Use dots in addition exercises with sums to 15 for those Ss who cannot read and pencil-and-paper representations for the other exercises, especially denominate numbers and fractions. However, paper and pencil with abstract symbols only can be used with these same exercises).

3. E reinforces every correct response by saying "That's right," "Right," or "Correct," and helps S secure correct responses one at a time in consecutive order until each correct answer is obtained. When S has learned to work the 10th exercise with E's assistance, E notes the time with the appearance of the last digit of the correct answer either as worked by S or by E if the maximum 1½ minutes was used. This then, is the time to learn. The first acquisition test is given immediately. The number correct in this test should also be noted in the blank labelled (incorrectly) 20-minute retention score. (An acquisition test should be limited to 5 minutes. Proceed immediately to IV.)

4. The first and subsequent acquisition or retention tests should allow up to 5 minutes for S to work the ten items. No help or assistance will be given except to Ss with low IQs where E may write the answers in response to S's oral answers. If the full 17 minutes of learning time is used by S, the first acquisition test would then be given immediately at the end of the 17 minutes learning period. If S uses less than 17 minutes, the learning time is noted and the first acquisition test is given immediately. In either case, the 5-minute rest or reading period follows. On all acquisition or retention tests, E should note the number worked correctly.

IV. Reading procedure

E gives S some books and says, "You've done well today. Here are some books to look at and read for a while. Which one do you like most?" (5 minutes) (May chat and converse with S about book or story, not about arithmetic task.)

V. Retention procedure

1. After 5 minutes say, "Here are the same exercises you did before. Let's see how many you can do again." E records the number correct. The procedure is limited to 5 minutes.

2. If S cannot independently get any exercise correct, record a 0 for retention score, except help as noted above for low IQ children where item may be read with E writing in answer.

SURVEY--ADDITION

1.	2 +3	4 +1	2 +4
2.	1 +6	5 +3	6 +3
3.	3 +9	6 +7	10 + 1
4.	4 +14	1 +18	13 + 6
5.	21 +20	43 +50	36 +43
6.	145 +652	630 +359	632 +227
7.	28 +46	24 +98	74 +46
8.	943 +128	467 +936	785 +598
9.	$1.48 + 3.89	$2.31 + 1.55	$4.33 + 9.38
10.	428 169 +899	183 441 +962	513 814 +339

11.	2 ft. 7 in. +1 ft. 2 in.	7 ft. 8 in. +1 ft. 5 in.	3 yd. 2 ft. 6 in. +7 yd. 2 ft. 3 in.
12.	1 qt. +2 qt. 1 pt.	5 qt. 1 pt. +4 qt. 1 pt.	3 gal. 1 qt. 2 gal. 1 pt. +5 gal. 1 qt. 1 pt.
13.	8 lb. 8 oz. +9 lb. 3 oz.	2 lb. 6 oz. +5 lb. 1 oz.	8 lb. 3 oz. +6 lb. 13 oz.
14.	2 hr. 29 min. +9 hr. 17 min.	6 hr. 27 min. +8 hr. 46 min.	22 da. 7 hr. 29 min. +10 da. 15 hr. 53 min.
15.	8 mo. 23 da. +2 mo. 3 da.	9 mo. 15 da. +2 mo. 25 da.	1 yr. 7 mo. 23 da. +5 yr. 6 mo. 2 da.
16.	$\frac{1}{3}$ $+\frac{1}{3}$	$\frac{2}{7}$ $+\frac{3}{7}$	$8\frac{5}{9}$ $+6\frac{2}{9}$
17.	$\frac{3}{5}$ $+\frac{2}{5}$	$8\frac{1}{7}$ $+7\frac{6}{7}$	$7\frac{4}{5}$ $+6\frac{2}{5}$
18.	$\frac{1}{2}$ $+\frac{1}{3}$	$5\frac{1}{3}$ $+6\frac{3}{4}$	$4\frac{3}{8}$ $+7\frac{5}{6}$

[illegible]

ACQUISITION AND RETENTION TASKS
IN ADDITION

1.	2 +3	4 +1	2 +4	4 +0	1 +3	6 +0	4 +2	0 +1	5 +1	1 +4	2 +1	3 +3	5 +1
2.	1 +6	5 +3	6 +3	0 +8	6 +2	7 +2	7 +0	4 +4	3 +7	2 +8	5 +4	7 +2	1 +7
3.	3 +9	6 +7	10 + 1	1 +11	6 +8	9 +3	6 +5	7 +4	11 + 4	13 + 2	15 + 0	2 +13	11 + 3
4.	4 +14	1 +18	13 + 6	9 +8	7 +10	11 + 8	1 +17	16 + 0	4 +13	8 +9	14 + 3	12 + 6	3 +14
5.	21 +20	43 +50	36 +43	46 +12	54 +45	30 +29	35 +24	47 +12	43 +25	24 +42	76 +22	16 +23	42 +53
6.	145 +652	630 +359	632 +227	369 +210	428 +311	432 +456	300 +208	562 +413	530 +245	341 +338	664 +203	124 +305	343 +142
7.	28 +46	24 +98	74 +46	38 +24	95 +25	67 +34	54 +38	65 +58	93 +22	72 +69	58 +32	83 +45	69 +22
8.	943 +128	467 +936	785 +598	268 +961	283 +748	495 +778	587 +131	989 +896	875 +182	878 +390	785 +598	763 +266	498 +167
9.	$1.48 +3.89	$2.31 +1.55	$4.33 +9.38	$5.23 +1.46	$9.73 +1.17	$4.95 +3.67	$4.33 +6.15	$3.13 +5.70					
				$9.37 +7.26	$6.10 +9.78	$8.91 +2.59	$8.14 +1.13	$7.54 +5.50					

10.	428	183	513	//	261	590	762	230	537	134	622	221	519	7
	169	441	814		269	837	970	674	350	503	500	543	517	5
	+899	+962	+339	//	+128	+599	+869	+431	+906	+404	+100	+183	+853	+9

11. 2 ft. 7 in.
+1 ft. 2 in.

7 ft. 8 in.
+1 ft. 5 in.

3 yd. 2 ft. 6 in.
+7 yd. 2 ft. 3 in.

//

9 ft. 6 in.
+2 ft. 1 in.

4 ft. 3 in.
+5 ft. 7 in.

7 ft. 4 in.
+3 ft. 3 in.

5 ft. 6 in.
+8 ft. 9 in.

4 ft. 8 i
+9 ft. 7 i

6 ft. 6 in.
+4 ft. 8 in.

4 yd. 1 ft. 11 in.
+ 5 yd. 1 ft. 7 in.

11 yd. 2 ft. 3 in.
+ 4 yd. 1 ft. 7 in.

3 yd. 2 ft. 11 in.
+4 yd. 2 ft. 5 in.

7 yd. 2 ft. 7 in.
+5 yd. 1 ft. 9 in.

12. 1 qt.
+2 qt. 1 pt.

5 qt. 1 pt.
+4 qt. 1 pt.

3 gal. 1 qt.
2 gal. 1 pt.
+5 gal. 1 qt. 1 pt.

//

2 qt. 1 pt.
+1 qt.

1 pt.
+2 qt. 1 pt.

4 gal. 3 qt.
9 gal. 1 qt. 1 pt.
+5 gal. 2 qt.

4 gal. 1 pt.
1 gal. 1 qt. 1 pt.
+2 gal. 1 qt. 1 pt.

2 gal. 3 qt. 1 pt.
7 gal. 2 qt.
+9 gal.

4 gal. 1 pt.
4 gal. 1 qt. 1 pt.
+3 gal. 1 qt.

4 gal. 1 qt.
3 gal. 3 qt. 1 pt.
+5 gal. 2 qt. 1 pt.

7 gal. 2 qt. 1 pt.
2 gal. 1 qt. 1 pt.
+7 gal. 1 qt. 1 pt.

4 gal. 3 qt. 1 pt.
1 gal. 2 qt.
+1 gal. 1 qt. 1 pt.

6 gal. 1 qt. 1 pt.
7 gal. 1 qt.
+9 gal. 3 qt. 1 pt.

13.	8 lb. 8 oz. +9 lb. 3 oz.	2 lb. 6 oz. +5 lb. 1 oz.	8 lb. 3 oz. +6 lb. 13 oz.	//

7 lb. 9 oz. +6 lb. 1 oz.	2 lb. 9 oz. +9 lb. 3 oz.	4 lb. 2 oz. +8 lb. 2 oz.	2 lb. 5 oz. +7 lb. 9 oz.	8 lb. 9 oz. +7 lb. 5 oz.
8 lb. 8 oz. +5 lb. 13 oz.	5 lb. 12 oz. +2 lb. 7 oz.	1 lb. 14 oz. +6 lb. 13 oz.	4 lb. 11 oz. +5 lb. 6 oz.	2 lb. 7 oz. +4 lb. 13 oz.

14.	2 hr. 29 min. +9 hr. 17 min.	6 hr. 27 min. +8 hr. 46 min.	22 da. 7 hr. 29 min. +10 da. 15 hr. 53 min.	//

2 hr. 40 min. +8 hr. 7 min.	9 hr. 28 min. +4 hr. 29 min.	2 hr. 35 min. +4 hr. 59 min.	6 hr. 48 min. +8 hr. 23 min.

13 da. 21 hr. 8 min. + 4 da. 10 hr. 7 min.	18 da. 17 hr. 29 min. + 2 da. 3 hr. 49 min.	14 da. 7 hr. 7 min. +11 da. 17 hr. 29 min.
7 da. 16 hr. 37 min. +13 da. 19 hr. 43 min.	4 da. 8 hr. 21 min. +19 da. 23 hr. 57 min.	5 da. 23 hr. 34 min. +11 da. 4 hr. 47 min.

15.	8 mo. 23 da. +2 mo. 3 da.	9 mo. 15 da. +2 mo. 25 da.	1 yr. 7 mo. 23 da. +5 yr. 6 mo. 2 da.	//

2 mo. 13 da. +9 mo. 8 da.	8 mo. 3 da. +2 mo. 16 da.	2 mo. 5 da. +7 mo. 4 da.	5 mo. 17 da. +4 mo. 25 da.	6 mo. 25 da +4 mo. 16 da

5 mo. 8 da. +4 mo. 29 da.	9 yr. 5 mo. 15 da. +2 yr. 4 mo. 19 da.	5 yr. 9 mo. 7 da. +8 yr. 4 mo. 13 da.

7 yr. 11 mo. 27 da. +2 yr. 3 mo. 15 da.	6 yr. 4 mo. 7 da. +3 yr. 10 mo. 29 da.

16. $\begin{array}{r}\frac{1}{3}\\+\frac{1}{3}\\\hline\end{array}$ $\begin{array}{r}\frac{2}{7}\\+\frac{3}{7}\\\hline\end{array}$ $\begin{array}{r}8\frac{5}{9}\\+6\frac{2}{9}\\\hline\end{array}$ $\begin{array}{r}\frac{1}{10}\\+\frac{1}{10}\\\hline\end{array}$ $\begin{array}{r}\frac{1}{7}\\+\frac{1}{7}\\\hline\end{array}$ $\begin{array}{r}\frac{3}{9}\\+\frac{5}{9}\\\hline\end{array}$ $\begin{array}{r}\frac{1}{5}\\+\frac{3}{5}\\\hline\end{array}$ $\begin{array}{r}6\frac{1}{9}\\+4\frac{1}{9}\\\hline\end{array}$

$\begin{array}{r}8\frac{1}{4}\\+7\frac{1}{4}\\\hline\end{array}$ $\begin{array}{r}5\frac{1}{3}\\+6\frac{1}{3}\\\hline\end{array}$ $\begin{array}{r}7\frac{3}{5}\\+9\frac{1}{5}\\\hline\end{array}$ $\begin{array}{r}6\frac{1}{9}\\+5\frac{7}{9}\\\hline\end{array}$ $\begin{array}{r}6\frac{2}{7}\\+7\frac{1}{7}\\\hline\end{array}$

17. $\begin{array}{r}\frac{3}{5}\\+\frac{2}{5}\\\hline\end{array}$ $\begin{array}{r}8\frac{1}{7}\\+7\frac{6}{7}\\\hline\end{array}$ $\begin{array}{r}7\frac{4}{5}\\+6\frac{2}{5}\\\hline\end{array}$ $\begin{array}{r}\frac{4}{5}\\+\frac{1}{5}\\\hline\end{array}$ $\begin{array}{r}\frac{7}{9}\\+\frac{5}{9}\\\hline\end{array}$ $\begin{array}{r}\frac{5}{6}\\+\frac{1}{6}\\\hline\end{array}$ $\begin{array}{r}\frac{2}{7}\\+\frac{6}{7}\\\hline\end{array}$ $\begin{array}{r}\frac{5}{8}\\+\frac{7}{8}\\\hline\end{array}$

$\begin{array}{r}5\frac{1}{4}\\+1\frac{3}{4}\\\hline\end{array}$ $\begin{array}{r}9\frac{2}{7}\\+1\frac{5}{7}\\\hline\end{array}$ $\begin{array}{r}2\frac{1}{6}\\+3\frac{5}{6}\\\hline\end{array}$ $\begin{array}{r}4\frac{3}{8}\\+3\frac{7}{8}\\\hline\end{array}$ $\begin{array}{r}8\frac{2}{9}\\+7\frac{8}{9}\\\hline\end{array}$

18. $\begin{array}{r}\frac{1}{2}\\+\frac{1}{3}\\\hline\end{array}$ $\begin{array}{r}5\frac{1}{3}\\+6\frac{3}{4}\\\hline\end{array}$ $\begin{array}{r}4\frac{3}{8}\\+7\frac{5}{6}\\\hline\end{array}$ $\begin{array}{r}\frac{3}{4}\\+\frac{7}{8}\\\hline\end{array}$ $\begin{array}{r}\frac{2}{3}\\+\frac{1}{9}\\\hline\end{array}$ $\begin{array}{r}\frac{3}{4}\\+\frac{1}{6}\\\hline\end{array}$ $\begin{array}{r}\frac{1}{2}\\+\frac{3}{5}\\\hline\end{array}$ $\begin{array}{r}\frac{5}{9}\\+\frac{1}{2}\\\hline\end{array}$

$\begin{array}{r}5\frac{1}{6}\\+6\frac{1}{3}\\\hline\end{array}$ $\begin{array}{r}11\frac{1}{2}\\+4\frac{3}{8}\\\hline\end{array}$ $\begin{array}{r}7\frac{3}{4}\\+13\frac{1}{8}\\\hline\end{array}$ $\begin{array}{r}3\frac{5}{6}\\+5\frac{3}{4}\\\hline\end{array}$ $\begin{array}{r}2\frac{5}{6}\\+7\frac{2}{5}\\\hline\end{array}$

APPENDIX G

INSTRUCTIONS AND RELATED FORMS FOR THE SUBTRACTION TASK

I. INTRODUCTION OF CHILD TO SITUATION.

Introduce pupil to GSR operator and then say, "We're going to do some arithmetic and other things today. With which hand do you write? All right, here's a pencil and paper you can use later. Let's put your other hand here and place this gadget on it. So, while you're here this is going to be on your hand. Does it feel all right?" (If pupil asks about the electrodes, say, "This is used to find out how your hand acts while you are working and playing.") Examiner engages child in conversation about school work, summer activities, and out-of-school activities for about three minutes after GSR operator sits down. GSR operator will indicate when the Examiner is to begin the survey.

II. SURVEY PROCEDURE.

A. For Children Who Can Read and Write Numbers and Know Subtraction Forms.

1. "Here are some problems in subtraction. Let's see how many you can work correctly. Work as fast as you can without making mistakes. Her is a pencil. Start now with number 1."

   a. Immediately preceding level 12, E says: "How many inches are there in a foot?" If S says 12, E says: "That's right. Now when you do these next problems, remember that there are 12 inches in a foot."

   b. If S does not know that there are 12 inches in a foot, assume that he cannot do the exerciees in level 12 but continue the survey.

   c. Preceding level 13, E proceeds similarly for yards and feet; i. e., "How many feet are there in a yard?....Now when you do these next problems, remember that there are 3 feet in one yard."

   d. Preceding level 15, E proceeds similarly for hours and minutes; i.e "How many minutes are there in an hour?"....

   e. Preceding level 16, E proceeds similarly for days and hours; i.e., "How many hours are there in a day?"....

2. E sits next to S to note his progress and to clarify the task but does not give help on problems.

3. S continues to work problems until 2 errors in any level are made in succession. E then directs S to work only the first item in each of the next five succeeding levels. If S gets one correct, E asks S to work the other 2 survey problems at this level. Should S get 2 items correct at this level, proceed with the survey. Otherwise, if he works only one correctly, return to the original level where he made two errors. Items at this level will be his new subtraction task to be learned.

4. During the survey E does no coaching, no mentioning of correctness of solutions. However, E may encourage S to try problems if S is diffident. After one encouragement, a child's restating he cannot do the exercise will be accepted.

B. For Children Who Are not Able to Read, Write, nor Recognize Subtraction Forms. (Pennies may be used only with children who with encouragement cannot perform Level 1. If a child performs Level 1 without pennies, pennies will not be used at any subsequent level. However, at Levels 2 and 3, pencil marks or dots will be used by E only in teaching. S may use marks or dots in acquisition and retention. E gives no help.

1. "Here are some problems. Let's see how many you can work. We will use pennies."

2. Sample procedure: "Here are six pennies. (Place them in a neat row.) Now take away 2 pennies. How many pennies do you have left? Write the answer here. (Pointing to page.)

3. S may count pennies whenever he wishes, but the examiner will never direct him to count the initial amount nor the remainder.

4. Cease the survey when S makes 2 errors in succession. Try the first item at the next higher level. If S gets the first item correct, proceed with the survey. If S gets none or one correct, return to the level where 2 errors were made originally. This level will be the new task to be learned.

III. Teaching procedure

A. For Children Who Can Read and Write Numbers and Know Subtraction Forms.

1. The task to be learned will include ten new items at the level where S made 2 errors in the survey.

2. Give S a copy of the items and a pencil.

3. E sits next to S and E also has a copy of the items.

4. E works the first item on his own (E's) paper and then S works it on his paper. Each of the ten items is similarly presented with E first working it and then S. Every correct response of S is reinforced with "Right," "Correct," or similar term.

5. Sample Teaching Procedures.

a. Levels 1 to 3. "Here is the first problem. It is 6 minus 3. Six minus 3 leaves 3. So I put down a 3 here. Now you do this same problem on your paper." E proceeds to each successive item within the level with the same teaching procedure.

b. Levels 4 to 6. "Here is the first problem. It is 17 minus 3.

Now I take 3 from 7 which leaves 4. So I write 4 here. There is nothing to be taken from the 1, so I bring the 1 here. The answer is 14. Now you do this same problem on your paper."

c. Levels 7 to 9. "Here is the first problem. It is 62 minus 24. I start subtracting here (pointing with pencil) but 4 is bigger than 2 so I have to borrow one ten from the 6 tens. I borrow one ten, cross out the 6 and write a 5, and put the 1 ten here so I have 12. Now, 4 from 12 leaves 8. Then 2 from 5 leaves 3. So the answer is 38. Now you work this same problem on your paper." S may look at E's paper if he wants to.

d. Level 11. "Here is the first problem. It is 11 feet 8 inches minus 9 feet 5 inches. We begin with the inches. We subtract 5 inches from 8 inches and write the 3 inches here. Now 9 feet from 11 feet leaves 2 feet. We write that here. The answer is 2 feet 3 inches. Now you do the problem on your paper." (Do not label answers with denominate numbers in order that unlabeled answers can be accepted in acquisition and retention tests.)

e. Level 12-16. "Here is the first problem. It is 10 feet 6 inches minus 4 feet 7 inches. We start with the inches, but we cannot take 7 inches from 6 inches. Therefore, we must borrow 1 foot from the 10 feet. Cross out the 10 and write 9. We change the foot to 12 inches, add it to the 6 inches and write 18 inches here. Now 7 from 18 leaves 11 inches. We write it here. Four feet from 9 feet leaves 5 feet. We write that here. The answer is 5 feet 11 inches. Now you do the same problem on your paper."

f. Levels 17-18. "Here is the first problem. It is 3/7 minus 2/7 This is similar to subtracting 2 pencils from 3 pencils and having one pencil left. Instead of pencils we have sevenths. We subtract the 2 from the 3 and get 1. So, we have 1/7 left as our answer. Now you work it on your paper."

g. Levels 19-23. "Here is the first problem. It is 1/2 minus 1/6. But we can't subtract sixths from halves, but the halves can be changed to sixths. Divide 2 into 6 and get 3. Multiply 3 times 1 and get 3. Write 3 here. So we have 3/6. Now 3/6 minus 1/6 is 2/6. Now you work it on your paper." (The child will be discouraged, as necessary, from reducing to simplest terms.)

h. In all teaching procedures emphasize the process in subtraction. E should do on his paper all the operations of which he speaks. When S works the item, he may look at E's paper. If S makes an error, E should point it out and help S correct it. E should not proceed to the next item until S has achieved the correct answer. The task is considered learned when the tenth problem is completed by the above procedures. E notes the total time spent in teaching on the summary form. Teaching time will vary from subject to subject, naturally.

i. A total of 2 minutes for the examiner's presentation and the child's working the problem may be devoted to each of the 10 items. Thus, a total of 20 minutes may be used. A minimum of 1 minute for the examiner's presentation and the child's working the problem should be used. Thus, a minimum of 10 minutes should be used for the 10 items.

B. For Children Who Are Not Able to Read, Write, nor Recognize Subtraction Forms.

1. The task to be learned will include 10 new items at the level where S made 2 errors in the survey.

2. Give S a copy of the problems and a pencil if he can write numbers.

3. Sample Procedure: (Levels 1 to 3) "Here are 6 pennies. (This is the first problem of the 10 to be learned. E may count the pennies or encourage S to count them.) Now you take away 3 pennies. How many are left?" (If S does not count the difference, encourage him to do so.)

4. E may record the answer if S cannot write numbers.

5. Proceed through the 10 problems to be learned.

IV. First acquisition procedure

Immediately after the tenth item has been completed, E gives S a duplicate copy of the items and says: "Now work these same problems. Work as fast as you can but try to get all the answers correct." E gives no help except that low-IQ children, when necessary, may be given pennies and E may record answers given verbally. For low-IQ children who cannot read the problem, E may lay out pennies in an amount equal to the minuend, then remove an amount equal to the subtrahend, and ask for the difference in words similar to those used in the survey. E may not, however, suggest that S do any counting. (Encourage S to try and to complete all items. If S says he cannot perform an item, encourage him twice and then accept his judgment that he cannot do it. Record the time required.)

On the first acquisition test and on subsequent retention tests the examiner should not score the paper in the presence of the child. If the child asks how many items he worked correctly, the examiner should indicate that he does not know because he has not scored the test.

V. The five-minute rest period

"Now we are going to listen to a story told to other boys and girls like you. I think it is a very good story so listen to hear every word of it." (GSR operator handles recorder.) Here E starts the recorded story of 4 minutes length.

VI. Five-minute retention test

When the recording is finished, give S a duplicate copy of the exercises. "Now work these same problems. Work as fast as you can but try to get all the answers correct." Give the child as much time as necessary to complete and record the time.

Child's Name ____________________

Date ____________Examiner ____________

SURVEY - SUBTRACTION (58-59)

1.	6 -5	4 -2	5 -3
2.	9 -6	8 -3	10 -3
3.	12 -9	14 -8	11 -2
4.	19 -6	14 -2	18 -5
5.	98 -45	67 -53	85 -40
6.	687 -415	675 -305	949 -527
7.	92 -47	64 -38	70 -56
8.	872 -329	586 -393	784 -465
9.	865 -279	673 -384	347 -248
10.	$8.84 -2.38	$6.57 -2.88	$9.18 -3.49
11.	8 feet 9 inches -3 feet 4 inches	6 feet 7 inches -2 feet 3 inches	8 yards 2 feet 9 inches -3 yards 1 foot 5 inches

12.	14 hours 33 minutes - 6 hours 18 minutes	7 hours 56 minutes -4 hours 49 minutes	13 days 18 hours 47 minutes - 7 days 8 hours 13 minutes
13.	10 feet 8 inches - 6 feet 9 inches	12 feet 3 inches - 4 feet 7 inches	9 feet 7 inches -6 feet 8 inches
14.	7 hours 18 minutes -2 hours 30 minutes	15 hours 28 minutes - 6 hours 39 minutes	12 hours 14 minutes - 8 hours 45 minutes
15.	6 yards 2 feet 6 inches -3 yards 1 foot 9 inches	7 yards 1 foot 9 inches -5 yards 2 feet 11 inches	4 yards 1 foot 7 inches -3 yards 1 foot 8 inches
16.	6 days 3 hours 9 minutes -2 days 15 hours 3 minutes	15 days 4 hours 20 minutes -7 days 23 hours 49 minutes	19 days 9 hours 10 minutes -12 days 21 hours 58 minutes
17.	$\frac{4}{7}$ $-\frac{3}{7}$	$12\frac{7}{9}$ $-5\frac{4}{9}$	$8\frac{7}{8}$ $-4\frac{1}{8}$
18.	$4\frac{5}{8}$ $-1\frac{7}{8}$	$4\frac{2}{5}$ $-2\frac{4}{5}$	$10\frac{1}{6}$ $-4\frac{5}{6}$
19.	$\frac{3}{4}$ $-\frac{1}{8}$	$\frac{2}{3}$ $-\frac{1}{9}$	$\frac{1}{2}$ $-\frac{3}{8}$
20.	$9\frac{7}{9}$ $-3\frac{1}{3}$	$5\frac{1}{3}$ $-2\frac{1}{6}$	$12\frac{3}{4}$ $-7\frac{3}{8}$
21.	$\frac{5}{6}$ $\frac{1}{4}$	$\frac{2}{3}$ $\frac{1}{8}$	$\frac{3}{4}$ $\frac{3}{5}$
22.	$5\frac{4}{5}$ $-4\frac{3}{4}$	$7\frac{2}{7}$ $-3\frac{2}{3}$	$4\frac{5}{8}$ $-1\frac{2}{3}$
23.	$95\frac{1}{6}$ $-27\frac{3}{7}$	$77\frac{5}{8}$ $-19\frac{7}{9}$	$63\frac{3}{8}$ $-17\frac{4}{5}$

DATA SHEET

Subtraction

Child's Name ______________________

Survey-Level Taught ______________ **Examiner** __________ **Date** ________

Time Spent in Teaching ______________________

First Acquisition Score ______________________

Time to Complete First Acquisition ______________________

First Retention Score ______________________

Time to Complete First Retention ______________________

Level of Aspiration Score ______________________

6-week Retention Score ______________ **Examiner** __________ **Date** ________

Time to Complete 6-week Retention ______________________

12-week Retention Score ______________ **Examiner** __________ **Date** ________

Time to Complete 12-week Retention ______________________

APPENDIX H

INSTRUCTIONS AND RELATED FORMS FOR THE DIFFERENTIATED PROBLEM-SOLVING TASK

I. Securing seven-week retention

"Remember, the last time you learned to do some problems in subtraction. Here are the same ten problems as last time. But first let me show you how you di one of them. . . Now work these same ten problems as fast as you can but try to get the answers right." (Demonstrate and orally explain Survey 1 item given on Data Sheet. Pennies are used with Level 1, dots or dashes with Levels 2-3, abstractions only Level 4 and beyond.) (E does not ask S to check or rework; gives no help except at Level 1 and 2-3, where E may point as necessary to the subtrahen and minuend and to successive items to be worked. If S states he cannot do it, encourage twice and proceed to next item.)

II. Survey of knowledge and skills related to change making

Score I _____ IV _____
II _____ V _____
III _____

Name ____________________
Examiner ____________________
Date ____________________

Instructions to child: "Here are some questions to find out what you know about numbers and money. I will read most of the questions and you tell me the answers." (Examiner simply checks each incorrect response and draws a vertical line to show where the child stops within each item and records above. Subsequentl teaches LL and L nothing; Average and High only what is necessary for Average to start Level 7 and High Level 8.)

1. Tell me quickly what each number is as I point to it.

4 3 5 7 6 9 8 10 11 17 10 14 19 12
18 24 22 28 32 45 58 64 77 86 99 105 119 124
136 162 178 596 1532

2. Tell me quickly what each number and amount of money is.

2¢ 1¢ $1 $2 $1.32 $5.75 $11.26 $22.45 $.01 $.11

3. Read each of the following words as I point to them.

a. penny b. nickel c. dime d. quarter e. half dollar f. dollar

4. Answer the following questions quickly:

(1) How many pennies are in a nickel?
(2) How many pennies are in a dime?
(3) How many nickels are in a dime?
(4) How many pennies are in a quarter?
(5) How many nickels are in a quarter?
(6) How many pennies are in a half dollar?
(7) How many dimes are in a half dollar?
(8) How many quarters are in a half dollar?
(9) How many nickels are in a half dollar?

(10) How many pennies are in a dollar?
(11) How many dimes are in a dollar?
(12) How many quarters are in a dollar?
(13) How many half dollars are in a dollar?
(14) How many nickels are in a dollar?

5. Work the following examples as quickly as you can.

(a) $\begin{array}{r} 2 \\ +3 \\ \hline \end{array}$ (b) $\begin{array}{r} 5 \\ +3 \\ \hline \end{array}$ (c) $\begin{array}{r} 10 \\ +10 \\ \hline \end{array}$ (d) $\begin{array}{r} 25 \\ +2 \\ \hline \end{array}$ (e) $\begin{array}{r} 25 \\ +5 \\ \hline \end{array}$ (f) $\begin{array}{r} 25 \\ +10 \\ \hline \end{array}$ (g) $\begin{array}{r} 25 \\ +50 \\ \hline \end{array}$

(h) $\begin{array}{r} \$2.25 \\ +1.55 \\ \hline \end{array}$ (i) $\begin{array}{r} \$1.50 \\ +3.75 \\ \hline \end{array}$ (j) $\begin{array}{r} \$3.40 \\ 2.75 \\ +1.93 \\ \hline \end{array}$ (k) $\begin{array}{r} 25 \\ 10 \\ 5 \\ +2 \\ \hline \end{array}$ (l) $\begin{array}{r} 50 \\ 25 \\ 10 \\ 5 \\ +2 \\ \hline \end{array}$ (m) $\begin{array}{r} 25 \\ 10 \\ 10 \\ 5 \\ 5 \\ +3 \\ \hline \end{array}$

III. Problem-solving task

"You know quite a bit about money. Now I have a problem for you to work that is about money."

(Go directly to Directions for Average and High, or to Directions for Low and Low Low as appropriate, reading the instructions with the child looking on to the same sheet. If S completes in less than 3 minutes, give next level problem without going through instructions again except if a high Low goes beyond Level 6. Tell child to use bottom of page only for adding. Use boxed area for placing in right number of coins.)

A. Cues for Low Low:

Answer questions first 3 minutes by restating problem verbatim. End of 3 minutes restate problem only.

1. End of 6 minutes, show S how 5 pennies make a nickel and then restate original problem.

2. End of 9 minutes, show S how to get N by adding upward from a nickel, one penny at a time. Show both how total amount and total N are obtained. Then put coins back in denomination groups and restate problem.

3. End of 12 minutes, show S how to do the problem, counting upward from a nickel. Leave only coins used near child; have him then repeat the solution. Do not ask child if he understands nor ask him questions while demonstrating the solution to the problem. Give the child an additional three minutes for solution and extra help.

B. Cues for Low:

Answer questions first three minutes by restating problem verbatim. End of 3 minutes restate problem only.

1. End of 6 minutes, tell S to begin with largest coin that does not

make more than the amount wanted and then to continue by using the next largest coin. Restate the problem.

2. End of 9 minutes, show S how to add two largest needed coins and how to check number of coins. Restate the problem.

3. End of 12 minutes show S how to do the problem, beginning with the largest coin and going to the smaller coins. Show him that both the amount and the number are correct. Have the child then solve the problem, using a new sheet, allowing an additional three minutes for solution and help.

C. Cues for Average and High:

Answer questions first 3 minutes by restating the problem verbatim. End of 3 minutes restate the problem, only.

1. End of 6 minutes, show S how to make up the required amount with the largest possible coins, and/or coins and bills. State, "Now this is the correct amount; your problem is to keep this amount but also to get the right number of coins."

2. End of 9 minutes, make up the correct amount with fewest coins and show S how to split 50¢ and 25¢ to get more coins. (This demonstration is apart from the demonstrated amount given S on his work sheet.) "To get more coins without changing the amount, I change 1 half-dollar to 2 quarters (use block below on separate work sheet) or I can change 1 quarter to 2 dimes and 1 nickel." (After the demonstrations, continue the problem. Point to his problem and restate it.) If S already has too many coins, show him how to decrease the number by combining coins.

3. End of 12 minutes, work the problem for S showing him how the correct amount is obtained by the procedure in Cue 1 and then how to get the correct N by the procedure in Cue 2. Show him that both the amount and N are correct. Then on a new work sheet write in the problem and have him work it. Do not ask child if he understands nor ask him questions during the demonstration. Give the child an additional three minutes for the solution and extra help.

IV. Five-minute listening:

"Now we are going to listen to a story told to boys and girls like you. I think you will enjoy it, so smile when you want to. Listen carefully now to the story."

V. Five-minute retention and/or transfer test:

"That was a good story, wasn't it?"

A. Retention: "Here is the same problem you did before the story. Do it as quickly as you can."
(Restate only the problem and enter the correct numbers on the sheet for the retention measure. Give the same helps as for acquisition except if child is proceeding correctly, give no help.)

B. Transfer: "Here is a problem like the one you did before but not the same one. Do it as quickly as you can." (Restate only the problem and enter the correct numbers on the sheet for the transfer measure. Give the same helps as for acquisition except if child is proceeding correctly, give no help.)

Child ______________________

Date ______________________

Examiner ______________________

Form B: Instructions, L and LL, Problem Solving, 1958-1959

Directions: (Lay out in front of child more than a sufficient number of coins in proper denomination groups, including half dollars, except for LL.) In the problem you are to work today, an amount of money is given first and then the numb of coins or pieces of money you are to use in making change. In making change, yo are always to use the biggest coins or pieces of money first. Notice the example. make 6¢ change with 2 coins.

To make 6¢ with 2 coins or pieces of money, I use 1 nickel and 1 penny. (Demonstr by taking coins from pile.) One nickel is 5¢ and 1 penny is 1¢. 5¢ and 1¢ make 6 the right amount. 1 nickel and 1 penny make 2 coins or pieces of money, the right number of coins. So I write in 1 here and 1 here. (Not necessary for LL.)

Here is your problem now. make __¢ using __ coins or pieces of money. (Enter and read the amount and the number of coins.) Tell me now what you are to do. (E may restate problem if S cannot within 15 seconds.)

Amount	Number of Coins	Half-dollar	Quarter	Dime	Nickel	Penny
6¢	2					

Child ______________________

Date ______________________

Examiner ______________________

Form A: Instructions, AVHI, Problem Solving, 1958-59

Directions: In the problem you are to work today, an amount of money is first given and then the number of coins that you are to use to get that amount. In making the amount with the right number of different coins, you will sometimes need to use 5 pennies instead of 1 nickel, 2 nickels instead of 1 dime, 5 nickels instead of 1 quarter, and so on. Notice the example...Make 19¢ with 7 coins.

To make 19¢ with 7 coins, I use 3 nickels and 4 pennies. (Enter the numbers) Three nickels are 15¢, four pennies are 4¢. 15¢ and 4¢ make 19¢, the amount wanted. Three nickels and 4 pennies make 7 coins, the number of coins wanted.

Here is your problem now. Make ___¢ using ___ coins (Enter the amount an number of coins below) Put in the right number of coins as I did. You will need to use some coins larger than nickels. You may use this lower part of the page for figuring if you want to. Tell me now what you are to do. (E restates problem if S cannot in 15 seconds.)

Amount	Number of Coins	$20 Bill	$10 Bill	$5 Bill	$1 Bill	Half dol-lar	Quar-ter	Dime	Nickel	Penny
19¢	7									

LIST OF PROBLEMS FOR TASK II ACCORDING TO DIFFICULTY

Level	Make this Amount of Money	with No. of Coins (Least and Specified)	Level	Make this Amount of Money	with No. of Coins and Bills (Specified Not Least)
A1a.	7¢	3	B7a.	46¢	7
b.	8	4	b.	45	8
c.	9	5	c.	57	9
A2a.	12	3	d.	53	7
b.	13	4	C8a.	$1.92	9
c.	14	5	b.	1.97	9
A3a.	46	4	c.	8.88	12
b.	47	5	d.	9.77	12
c.	48	6	C9a.	12.49	14
A4a.	42	5	b.	12.63	14
b.	43	6	c.	14.53	16
c.	44	7	d.	14.87	16
A5a.	87	5	C10a.	26.48	18
b.	88	6	b.	27.47	18
c.	89	7	c.	29.62	19
A6a.	82	5	d.	28.82	19
b.	83	6			
c.	84	7			

DATA Sheet For Subtraction Retention and for Change Making, Problem-Solving.
Subtraction Survey Item:

Subtraction Level:

6 week Score ____________ Time to Complete Subtraction Retention __________
Does S have essential Survey Knowledge and Skill? Yes __ No __ Refer ________
Change-Making Assignment; encircle final selection.
Problem ________ Transfer Problem ________ Retention ________
1st. alt. ________ ________ ________
2nd. alt. ________ ________ ________
Sequence to final selection: 1st __, 2nd __, 3rd __, 4th __
Last Level of Help __________ Time to Solve __________
5-Min. Retention Time __________ Last Level of Help ________
5-Min. Transfer Time __________ Last Level of Help ________
Level of Aspiration Score __________
Date of 6-week Retention and Transfer ______ Examiner __________
6-week Retention Problem ________ 6-week Retention Time __________
6-week Transfer Problem ________ 6-week Transfer Time __________
Level of Aspiration Score ________
Any notes from Data Sheet from First Subtraction Test:

APPENDIX I

INSTRUCTIONS AND FORM FOR HANDWRITING TEST

Date____________________ **Teacher's Name**____________________

Your Name____________________

I am going to give you a pencil and sheet of paper. Write the date, your name, and the teacher's name. Your teacher has put a sentence on the board. When I say Start, write it as well as you can and as fast as you can until I say Stop. (Five minutes) Use every line of the paper. Also, after you write the last word, dog, start again with, A quick...on the same line. Notice how your teacher has done this on the board. Here is the sentence; remember you are to write it as well as you can and as many times as you can until I say Stop. I have more pencils and paper; if you need any, come up and get it. "Start... 5 minutes...Stop."

A quick brown fox jumps over the lazy dog.

APPENDIX J

INSTRUCTIONS AND RELATED FORMS FOR
THE SOCIOMETRIC TEST

Before administering (handwriting) test to a group, say:

"Today is a friendly sort of a day. Most of us like other boys and girls on a friendly day. Some of us have especially good friends in this class. Some of us have one; some of us have more than one. I will give you a sheet of paper that has the names of all the children. Get your pencil ready to do whatever I tell you. Do not touch this paper though until I tell you to."

Distribute class list, names down.

"Turn the paper over now. Write your name here, the teacher's name, and the date. (Demonstrate.) Now let's read the names of every child out loud, starting at the top. Ready? Let's read them together."

"Now underline the names of your good friends, like this." (Demonstrate.)

"If you need help in reading a name, hold up your hand. Start now and underline the name of each of your good friends. It may be one or more than one."

Examiner moves quickly about room to make certain that each child is underlining and can read all names. Also, Examiner invites classroom teacher to assist. After the first child has finished, give about one additional minute, then:

"Has everyone finished? I will give you about one more minute, finish as quickly as you can." Examiner and teacher circulate to help slow ones and at the same time prevent others from talking or comparing.

"Turn your papers over now. I will pick them up."

After picking them up, say:

"We are going to do some things together. I want to see how well good friends in a class like this behave."

Examiner must make certain that

1. Every child can read every name.
2. Every child writes his own name on paper. (We don't know who it is otherwise.)
3. Every child underlines names of friends.
4. No child looks at another's paper.
5. No child discusses choices with another child.
6. The testing is done very quickly and then the group moves to something else, so they may perhaps forget about what they did in the sociometric test.

Instructions for Second Sociometric Test, to Follow Immediately after First Test

After gathering the papers where friends' names are underlined, say:

"Now I am going to give you another sheet of paper with each child's name on it." (Pass out sheets.) "Write your name on the top of the sheet now." (Be certain low IQ names are identifiable.)

"This time put a 1 before the name of your best friend, a 2 before the name of your second best friend, a 3 before the name of your third best friend, a 4 before the name of your fourth best friend, and a 5 before the name of your fifth best friend. (Demonstrate on board, putting in 10 first names not from the list and then a random arrangement of 1, 2, 3, 4, 5 as choices.)

"You are to make 5 choices; finish as quickly as you can so that we can do something else."

Examiner, securing teacher help as necessary, makes certain each child responds and that each paper is identifiable. No child should be forced to put in 5 choices. One to five choices are accepted. Help is given to low IQ children as necessary, including working with each child individually if necessary.

Examiner will leave additional class lists, instruction sheet, and envelope with teacher for securing and sending to us responses of absentees; the same procedure will be used for absentees in handwriting.